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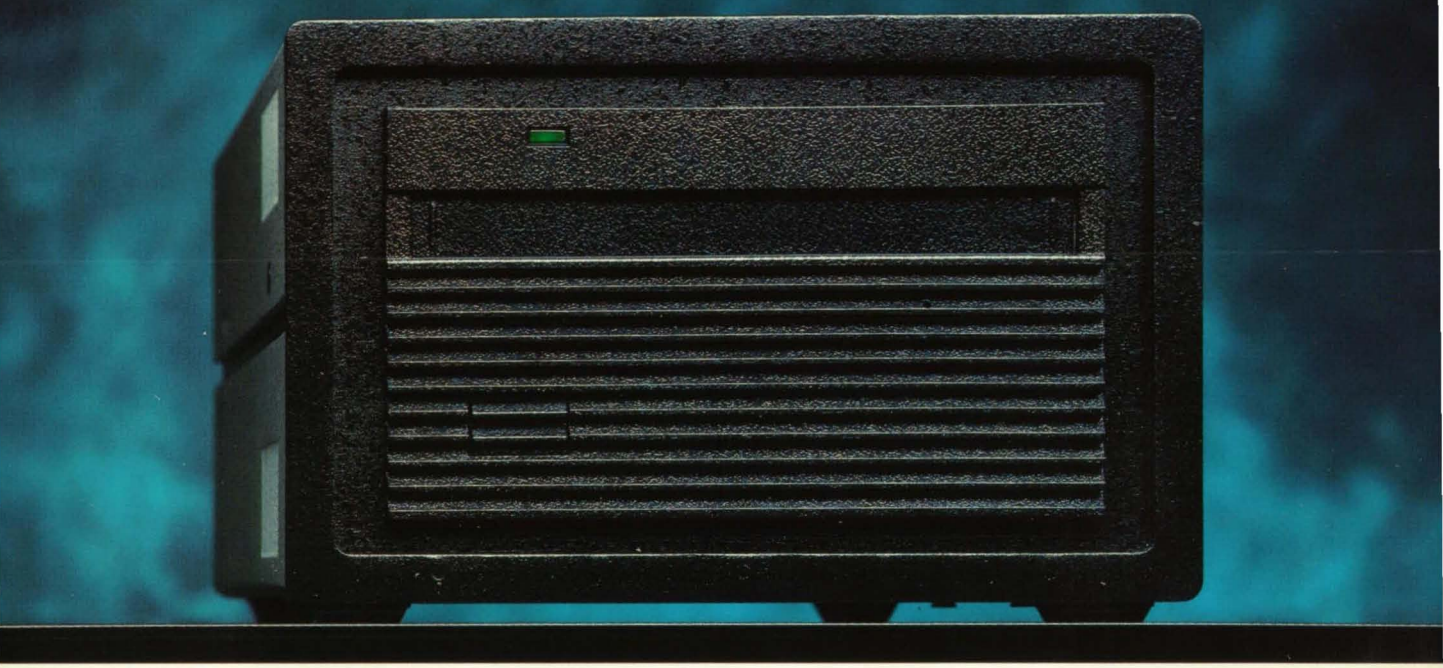

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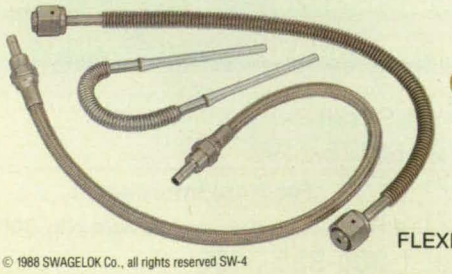

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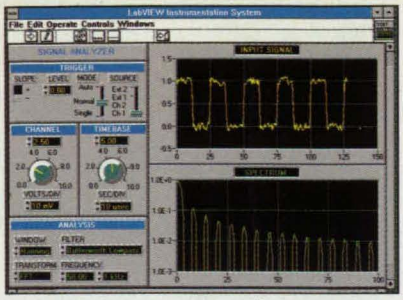

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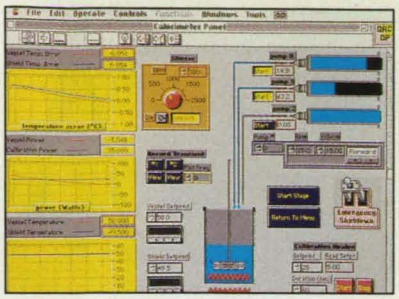

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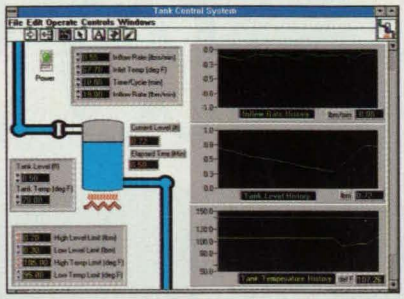

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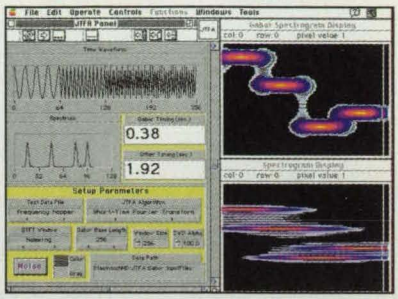

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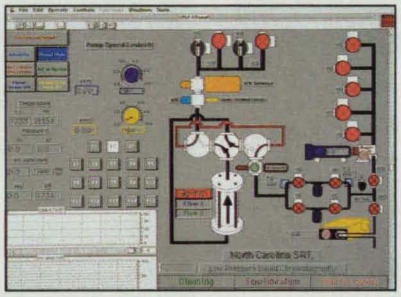

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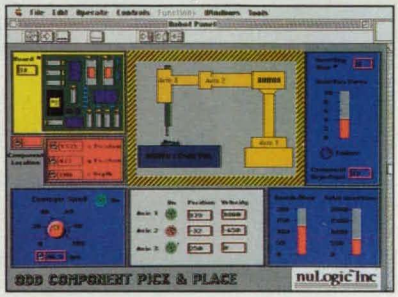

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It would have immense storage and memory capacity. And it would have features like high-performance networking and accelerated video support built in.

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You would make it flexible enough to run any kind of application. Affordable enough to put on every engineer's desk. And as long as you're fantasizing here, you'd make it as easy to set up, easy to learn and easy to use as an Apple® Macintosh® personal computer.

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By any measure, the Macintosh Quadra 700 and 950 are two of the most powerful personal computers ever built. Both are based on the Motorola 68040 (rated at 20 and 25 MIPS, running at 25 and 33 MHz), which integrates the processor, math coprocessor and RAM cache all onto one chip.

They're up to twice as fast as any of their forebears. Fast enough to beat the chips off comparably priced 486 computers from IBM, Compaq and Dell.* And fast enough to make programs like AutoCAD, MicroStation Mac,® MacBRAVO! and VersaCAD perform at a level once seen only in dauntingly complex workstations.

Built-in 24-bit video lets you create photo-realistic images without the expense of an extra card.

High-performance subsystems provide built-in support across the board: Ethernet networking, accelerated 24-bit video** support and faster SCSI and NuBus™ slots.

You can add a 400MB hard disk to both

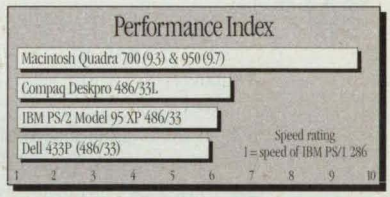
*"Comparisons are based on a 1991 independent research study conducted by Ingram Laboratories that tested a variety of personal computers running applications available for both the Macintosh and Microsoft Windows 3.0 environments. **24-bit video support for up to a 16" product specifications and descriptions were supplied by the respective vendor or supplier. Orbiter images created by Jerry Flynn. ©1992 Apple Computer, Inc. Apple, the Apple logo, A/UX, Mac, Macintosh and "The power to be your best" are registered trademarks and Macintosh Quadra and is a trademark of Wolfram Research, Inc. MicroStation is a registered trademark of Bentley Systems Inc. MS-DOS is a registered trademark and Windows is a trademark of Microsoft Corp. Motorola is a registered trademark of Motorola Corp. NuBus is a trademark of Texas Instruments.*

with the power revolution.

communications architecture lets you easily take advantage of features like distributed processing, allowing programs like RenderPro and BackBurner to utilize excess CPU cycles on other Mac computers or workstations for faster renderings.

There are two Macintosh Quadra models. The 950 sits next to your desk; the 700 fits on top of it.

And Macintosh Quadra fits in with the PCs you already own. The built-in Apple SuperDrive,™ used with Apple's new Macintosh PC Exchange software, allows you to share files easily with MS-DOS PCs via floppy disk or over a network. And with Apple's fully compliant version of UNIX®—A/UX®—you can even run UNIX, X Window, MS-DOS and Macintosh programs all at the same time.



Macintosh Quadra significantly outperforms 486 PCs from IBM, Compaq and Dell running Windows 3.0.

It all adds up to the kind of power that moved *PC Week* to give the Macintosh Quadra its highest satisfaction rating in the categories of overall performance, price relative to performance, expansion capability and ease of installation and configuration.†

the 700 and the 950 to accommodate the largest CAD files. And the 950 even lets you add a CD-ROM drive or a removable cartridge drive, and a disk array or more than a gigabyte of internal hard disk storage.

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November 1992
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TECHNICAL SECTION

(Continued on page 8)

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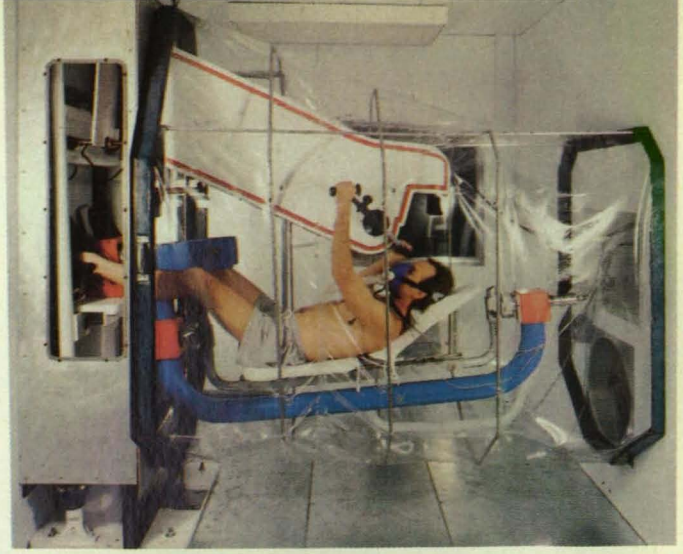

Photo courtesy NASA Ames

Ames Research Center has produced an exercise machine that trains astronauts' upper body muscles for extravehicular activity in orbit. The invention has applications in the sports fitness market and in rehabilitation. See the tech brief on page 120.

ABP BPA

DEPARTMENTS

on the cover:

This model of the flow within a complex 3D ram accelerator was generated using a novel data visualization software package developed with NASA's aid. The flow field consists of chemically reacting premixed methane and air, high supersonic velocities, viscous boundary layers, reflecting shock waves, combustion fronts, and extremely complex 3D interactions between the projectile fins and tube wall. Turn to Mission Accomplished, page 12.

Photo courtesy Amtec Engineering Inc

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Japan will benefit from expanded communications services, with two new satellites scheduled to be launched in 1994 and 1995. The satellites, built by Hughes Aircraft Company, will be three-axis, body-stabilized HS 601 models — Hughes' latest satellite design. They will each carry 24 Ku-band transponders, providing greater data, telephone, and video transmission throughout Japan. The HS 601 model is an extremely high-power satellite developed for applications such as direct television broadcasting to small receiving antennas, very small aperture terminals for private business networks, and mobile communications.

Integrated circuit manufacturers will be able to design faster, smaller electronic components — for higher output — now that Hughes has developed a precision method for thinning bonded Silicon-on-Insulator (SOI) semiconductor wafers. This new AcuThin™ process thins wafers to optical tolerances through a non-contact fabrication technology called Plasma Assisted Chemical Etching (PACE), also developed by scientists at Hughes. It yields a wafer with silicon film thickness of less than 100 nanometers — and uniformity of +/- 10 nanometers or better. It also preserves all bulk silicon properties, so manufacturers do not have to retool their fabrication equipment. Hughes has begun producing these new wafers for customers' initial process evaluation.

In the first full-scale "disaster drill" simulating a failed satellite transponder, Hughes satellite and network controllers restored a Disney feed placed on Galaxy II, transponder 4, after customer Upsouth Atlanta had intentionally dropped the feed as part of the drill. The object was to test satellite operating instructions and staff response, to see if any deficiencies existed. There was no disruption of programming to Upsouth Atlanta, as Hughes immediately coordinated with the Galaxy Program Office and moved the Upsouth feed to another Galaxy transponder. Restoring service to the primary transponder was completed in two minutes.

Government relief efforts in the Philippines were enhanced greatly by VSAT terminals, following the volcanic eruptions of Mount Pinatubo. These very small aperture terminals, built by Hughes, were used to transmit seismic data to geologists, as well as relay information regarding those left homeless. The earth stations are owned by the Philippine's Clavecilla Radio, which operates a network of more than 60 satellite earth stations in the Philippines. The terminals are C-band versions of the Personal Earth Station, Hughes' flagship satellite networking terminal for interactive voice and data transmission.

Major industrial plants in the United States are now benefitting from Hughes technologies that are providing environmental solutions. These technologies include thermal imaging to detect vapor spills, laser spectrometers for monitoring gas emissions, and fiber optic leak detectors. Hughes is actively involved in a Superfund cleanup project at a major U.S. industrial plant where it is providing systems engineering, remediation planning, technology application and environmental laboratory support, as well as helping manage these efforts. These innovative, science-based solutions draw upon many of Hughes' defense and non-defense technologies.

For more information write to: P.O. Box 80032, Los Angeles, CA 90080-0032

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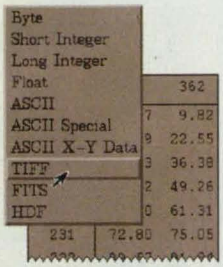

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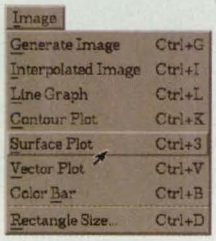

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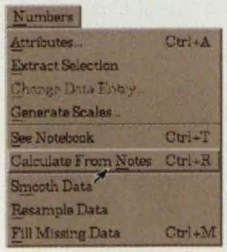

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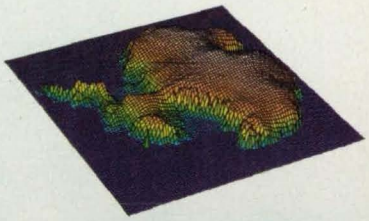
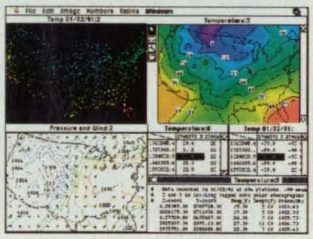
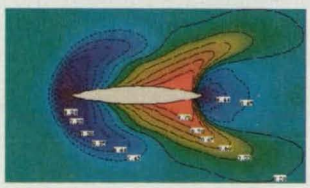


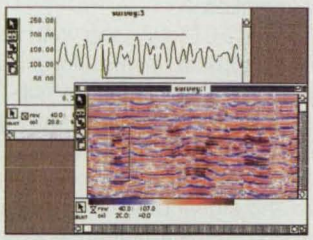
Surface elevation of Antarctica
Data: Professor Doug MacAyeal, Univ. of Chicago



U.S. Weather, January 2, 1991
Data: University of Illinois at Urbana-Champaign
Dept. of Atmospheric Sciences



Simulation of wind flow over an airfoil at Mach 0.5
Data: Dr. Mark Christon, Lawrence Livermore Labs



Slice from 3D seismic survey
Data: Halliburton Geophysical Services, Inc.

The Data Handbook

A Guide to Understanding the Organization and Visualization of Technical Data

by Brand Fortner ($39.95)

This indispensable reference provides an overview of the data universe. You'll also find useful information on specific formats like SEG-Y, Plot 3D, ACR-NEMA, netCDF, PICT, IGES, DXF, and others. *FREE* when you purchase Spyglass Transform, or order separately (allow 4-6 weeks for delivery).

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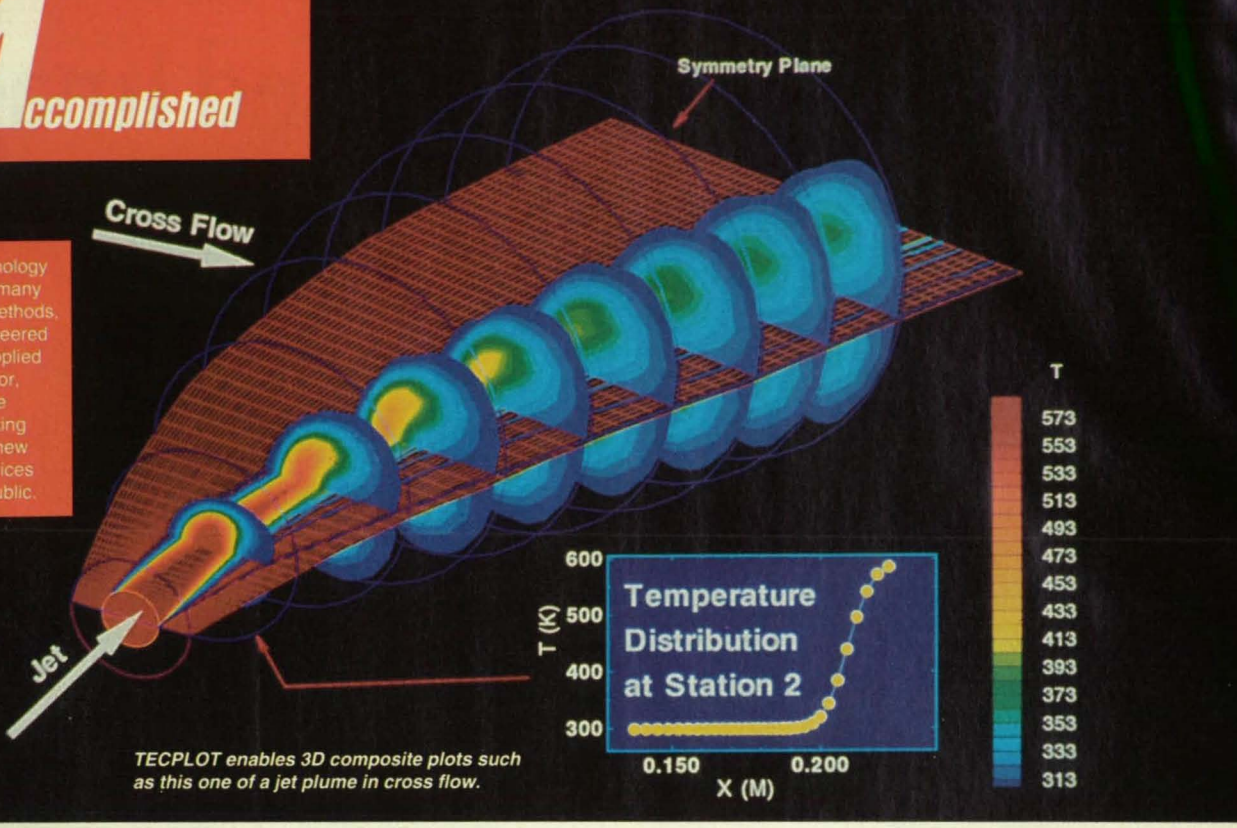
Mission Accomplished

Through the technology transfer process, many of the systems, methods, and products pioneered by NASA are reapplied in the private sector, obviating duplicate research and making a broad range of new products and services available to the public.



TECPLOT enables 3D composite plots such as this one of a jet plume in cross flow.

Today's sophisticated computations often generate mountains of data—far more than any person could visualize mentally. Software designed by Amtec Engineering Inc., Bellevue, WA, can create computer images from data tables containing millions upon millions of numbers, enabling the scientist or engineer to quickly examine the data for important features, trends, and anomalies.

Called TECPLOT, the interactive, menu-driven, data visualization program integrates X-Y plotting with two- and three-dimensional surface plotting capabilities. Flexible and easy-to-use, it has applications in test engineering, image and signal processing, process monitoring, medical diagnostics, scientific research, financial analysis, and energy exploration. It is particularly useful for analyzing computer simulations of fluid flows, electromagnetic fields, and heat conduction.

TECPLOT originated in 1984 as an in-house program to help Amtec better conduct R&D projects for commercial and government clients. "We designed it to anticipate what the user will want to do—to think like an engineer," said Byron Ponten, senior programmer at Amtec and the software's creator. After many clients such as NASA and Boeing had seen the results, they wanted the software for themselves and soon a commercial product was born.

According to Amtec president Michael Peery, TECPLOT stands out from most commercial programs in its ability to plot nonrectangular data structures, eliminating the need to interpolate data onto a rectangular grid. Interpolation of nonlinear data such as that acquired in computational fluid dynamics (CFD) can result in a loss of potentially important details.

Most plots are generated in seconds, and the user can interrupt to make alterations in the plotting configuration. Data can be subdivided into as many as 2048 subsets, or "zones," and then selectively plotted. The zones may represent physical objects, different versions of the data, or parts of a larger plot and can be displayed using a variety of plot types—including X-Y, contour, vector field, mesh, and scatter. These plots can be simultaneously displayed in up to 16 windows.

Multiple plots can be overlaid for analysis. Air flow data from wind tunnel tests, for example, can be superimposed on data from a computerized simulation of airflow. In this way, the experimental data can be used to confirm the utility of a simulation program.

TECPLOT runs on most UNIX and VMS workstations as well as PCs with DOS and UNIX, and is compatible with many other programs. For example, TECPLOT serves as the graphical user interface for INCA, Amtec's recently released CFD software.

TECPLOT 5, the latest release, incorporates many customer-requested features. According to Peery, NASA's Langley Research Center has been a primary source of user feedback, serving as a beta test site and suggesting such enhancements as 3D capability and porting to workstations. TECPLOT 6, scheduled for release in early 1993, will provide 3D volume capability for structures having an inside. Development of this feature was supported by a Small Business Innovation Research grant from Langley.

The program's versatility is illustrated by recent applications. NASA Langley has used it for space shuttle and space station research, satellite studies, rarefied gas dynamics studies, and even management of electricity demand. Los Alamos National Laboratory used TECPLOT to develop computer codes to help improve the safety and efficiency of nuclear facilities. The US Geological Survey employed it to analyze data generated from a multi-county groundwater study in the Florida panhandle. And oceanographers at Oregon State University used it to create large-scale ocean models. ❑

Editor's note: Amtec Engineering will demonstrate TECPLOT at Technology 2002, the third national technology transfer conference and exposition, to be held December 1-3 in the Baltimore, MD convention center.

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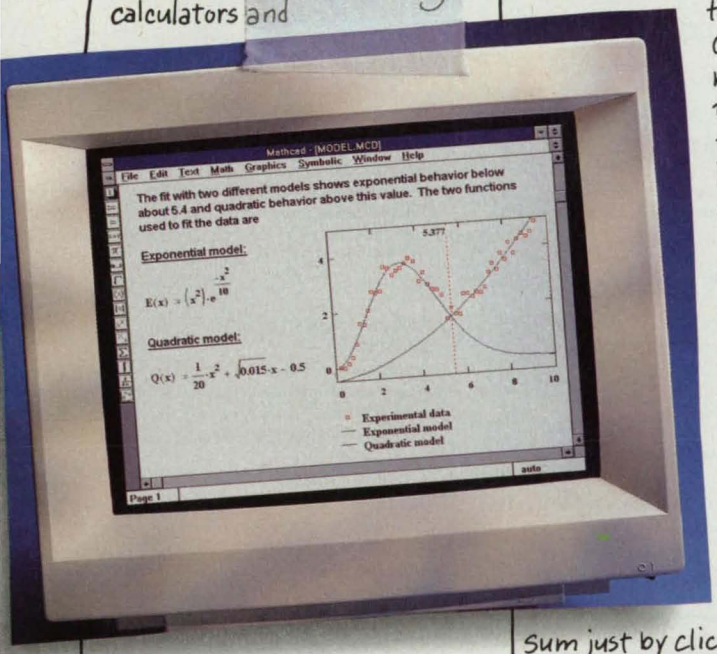

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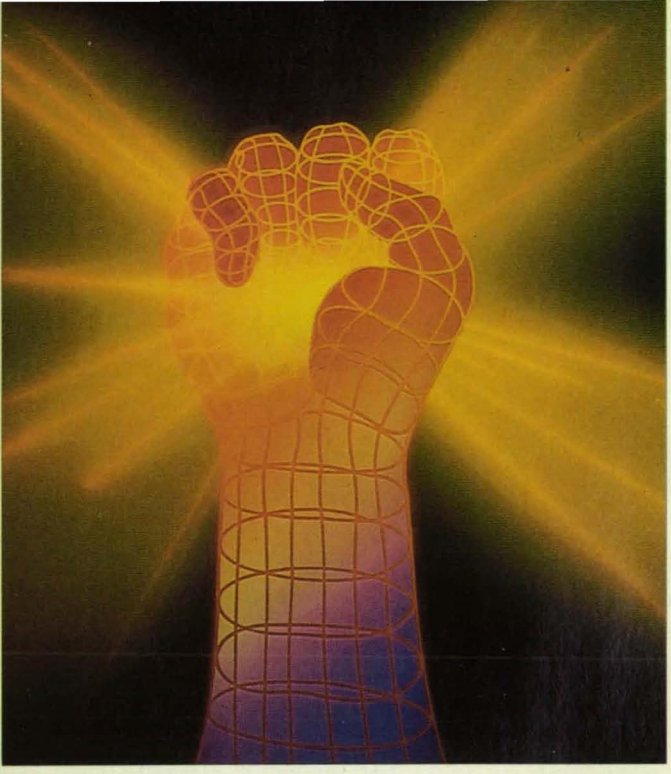


TECHNOLOGY 2002

Exhibits Preview

Technology 2002 (December 1-3, 1992, Baltimore, Maryland convention center) will be the largest technology transfer conference and exposition ever held, with 60,000 square feet of exhibits displaying new inventions and products available for license or sale. Following is a directory of the more than 200 federal government, university, and industry exhibitors who will be showcasing their latest and greatest technologies at this NASA-sponsored event.

BOOTH

Addison-Wesley Publishing Company 1101
Reading, MA
Literature will include *Mining the Nation's Brain Trust*, focusing on how to access the technical resources in federally funded or managed research labs, and *Concurrent Engineering*, describing this method of concurrently designing the product and its production, marketing, and support processes.

Advanced Digital Imaging 1101
Irvine, CA,
will present the AD1 digital disk recorder, which plays seven minutes of video with Betacam and D1 compatibility.

Advanced Technology & Research Corp. 222
Laurel, MD,
provides engineering services in defense, aerospace, and automation systems for NASA, DOD, USPS, and other agencies. The firm specializes in analysis, design, fabrication, and testing.

AECL Technologies 1101
Rockville, MD,
will feature the Open Architecture Distributed Computer System, a versatile and highly-reliable generic instrumentation and control system originally developed for nuclear power plants.

Aerospatiale 1023
Les Mureaux Center, France,
will highlight its role in principal European space projects and exhibit new products and technologies in such areas as thermal protection, magnetic bearings, and HP filament winding.

AFCEA 1223
Fairfax, VA,
is a nonprofit international organization representing government, industry, and military professionals in the fields of communications, computers, imaging, intelligence, and information systems.

AGEMA Infrared Systems 224
Secaucus, NJ,
will exhibit the Thermovision® 900, a high-definition, infrared thermal measurement system featuring built-in high-speed, 12-bit digital dynamic recording.

BOOTH

Allied-Signal Aerospace Company 906
Kansas City, MO,
will highlight its process capabilities in electrical-electronic, mechanical, and rubber and plastic products.

Ambassador Marketing 306
National City, CA,
will display bacteriostatic water treatment units incorporating technology originally developed for the space shuttle.

American Ceramic Society 200
Westerville, OH
Literature will highlight society meetings and expositions, publications and books (including advertising opportunities), continuing education, reference services, and membership.

American Microwave Corp. 1101
Frederick, MD
The firm's product catalog includes DLVAs and SDLVAs, PIN diode switches, and PIN diode attenuators.

American Welding Society 509
Miami, FL,
will spotlight the society's annual convention, as well as its educational seminars and conferences. Available literature will include the *Welding Journal* and AWS codes and standards.

Amerinex Artificial Intelligence Inc. 1101
Amherst, MA
Literature will describe products and services for vision automation including the KBVision™ system, which provides rapid prototyping and development tools as well as libraries to create application-specific software modules.

Ames Research Center 528
Moffett Field, CA,
will showcase the Electro-Expulsive Deicing System for shipboard and aircraft use and a compact, modular measurement system for physiological and spaceflight applications.

BOOTH

Amtec Engineering Inc. 726
Bellevue, WA,
will feature TECPLOT, an interactive, menu-driven data visualization program for creating X-Y, contour, vector, scatter, and mesh plots in 2D and 3D, and INCA, a 3D Navier-Stokes flow analysis program.

Andrews Glass Company 1101
Vineland, NJ
A brochure will describe the firm's precision glass and quartz fabrication capabilities, including precision cutting, grinding, and polishing; bore tubing; metal sealing; graded seals; and hand tooling.

Arthur D. Little Inc. 1101
Cambridge, MA
Literature will describe future space program planning and development, thermal control hardware, flight experiments, space science, EVA materials technology, and systems development, as well as the space station laundry and refrigerator project.

Association of American Railroads 312
Pueblo, CO,
will highlight a variety of R&D programs for rail transportation conducted at the Transportation Test Center.

ASTM 1101
Philadelphia, PA
The ASTM publications catalog describes the 68 volumes of the Annual Book of ASTM Standards and several hundred related technical publications.

Astro-Med Inc. 126
West Warwick, RI,
will exhibit advanced chart recorders including the MT95K2 8-32 channel recorder with monitor and Dash 8 and Dash IV portable field recorders.

Austrian Embassy 1109
Washington, DC
The embassy and Austrian Trade Commission provide assistance in trade between the US and Austrian companies and institutions.

BOOTH

Aviation Week & Space Technology 1101
New York, NY,
is a weekly news magazine for the aviation/aerospace business reporting on a range of industries including commercial, military, defense electronics, and space.

Bergen Cable Technologies Inc. 1101
Lodi, NJ
Literature will describe Bergen's safety cable, a cost-effective alternative to lockwire for fastener retention that offers a 50 percent labor savings and has no sharp edges.

BEST North America 1101
Baltimore, MD
The company's on-line research database profiles faculty research expertise and technologies from more than 125 major North American universities and research institutions.

BF Goodrich Aerospace 622
Vengennes, VT,
will exhibit aerospace components for commercial, military, and space vehicles.

Biophysics Research Foundation 728
Edgewood, IL,
will display neural pattern enhancement equipment and technology that employs brain mapping, evoked response, and delta-state conditioning to reprogram brain patterns and enhance abilities.

Biotronics Technologies 506
Waukesha, WI,
will feature on-line systems for simultaneous, multi-component analysis of chemical constituents in water using absorption and liquid atomic emission spectrometry.

Birch, Stewart, Kolasch, and Birch 1101
Falls Church, VA
Literature from this intellectual property law firm details assistance available to inventors, engineers, and designers in obtaining, licensing, and enforcing US and foreign patent rights.

Boeing Company 128
Huntsville, AL,
will exhibit components of space station Freedom including a glove box, a plant and animal habitat, a biomedical monitoring rack, and a 2.5-meter centrifuge.

Boeing Company 510
Seattle, WA,
will demonstrate EASY5 software, a GUI-based package for dynamic system modeling, simulation, control system analysis, and design applicable to large and complex continuous, digital systems.

Booz-Allen & Hamilton 909
Bethesda, MD,
will highlight efforts in its space systems division to consolidate civilian space engineering and operations, space and strategic defense technology, satellite systems, and technology transfer.

Brookhaven National Laboratory 708
Upton, NY,
focuses on basic and applied research in the physical, biomedical, and environmental sciences and in selected energy technologies.

Business Communications Company Inc. 1101
Norwalk, CT
The BCC catalog contains information on over 250 business opportunity reports, newsletters, directories, and conferences in such fields as waste, energy, chemical, biotechnology, health care, optics, materials, electronics, and communications.

BOOTH

California Institute of Technology 408
Pasadena, CA
As a member of the National Consortium for Concurrent Supercomputing, Caltech will present recent scientific results obtained using the Intel Touchstone Delta Supercomputer.

Canon Communications Inc. 1010
Santa Monica, CA,
is the primary source of news and information for the medical products and electronics manufacturing industries with its trade publications *Medical Device & Diagnostic Industry*, *Medical Product Manufacturing News*, and *Microcontamination*.

C I Systems Inc. 107
Hawthorne, NY,
will demonstrate its line of blackbody reference sources and the SR-5000, a computerized spectroradiometer.

C.ITOH Technology Inc. 314
Irvine, CA,
will display a multifunction, programmable graphic LCD key switch with multicolor LED backlighting, and various prototype and design tools to shorten design time.

Concurrent Technologies Corp. 221
Johnstone, PA,
provides technical metalworking services to industry and government, developing ways to produce net shape parts and their manufacturing processes correctly the first time in an efficient, environmentally safe, and cost-effective manner.

BOOTH

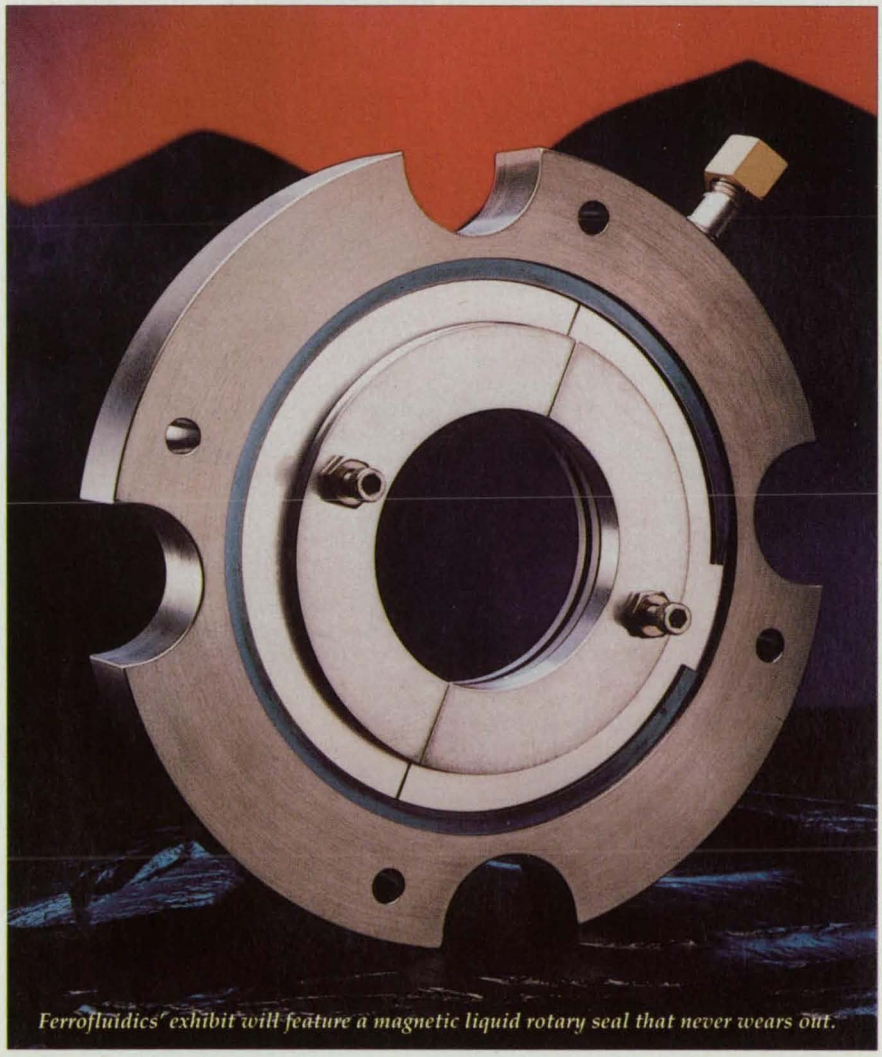
Control Systems Analysis 1101
Middletown, RI
Literature will present INTERLOCKS™, a powerful, clear-cut methodology and tool for specification and analysis of complex control systems.

Cornell Theory Center 821
Ithaca, NY
The four National Science Foundation (NSF) Supercomputer Centers have joined together at Cornell as the NSF Metacenter. The exhibit will offer information about this national resource and highlight ongoing research projects.

Corning Inc. 210
Corning, NY
Corning's Technology Sales and Licensing Group will describe the company's analytical and engineering services and its patented technologies available for sale or license.

Corptech 1101
Woburn, MA
The *Technology Industry Growth Forecaster* uses current data from technology executives to provide monthly insights into the technologies and geographic areas with the fastest projected growth during the upcoming year.

COSMIC/The University of Georgia 721
Athens, GA
NASA's Computer Software Management and Information Center (COSMIC) will demonstrate software developed or funded by NASA and available to industry, academia, and government.



Ferrofluidics' exhibit will feature a magnetic liquid rotary seal that never wears out.

BOOTH

County of Loudoun, Virginia 309
Leesburg, VA,
will provide information on relocation and expansion services as well as demographics, taxes, building sites, and buildings.

CTA Inc. 1101
Rockville, MD
A special edition of the company's magazine *Tech News* will focus on CTA technical support to NASA.

Cybernet Systems Corp. 114
Ann Arbor, MI,
will demonstrate the PER-Force™ handcontroller with virtual force-feedback, suitable for hazardous environments, and the Interface Evaluation System for advanced cockpits.

Daedalus Enterprises Inc. 1101
Ann Arbor, MI
Literature will describe two new commercial scanner products from this manufacturer of airborne multispectral imaging systems.

BOOTH

Diamonex 611
Allentown, PA,
will exhibit diamonds and diamond coatings for optical and thermal applications, and chemical- and abrasion-resistant coatings for metal, glass, ceramic, and plastic substrates.

Digiray Corp. 508
San Ramon, CA,
will display an all-electric, real-time x-ray system based on reverse geometry. It uses a scanning beam of electrons to produce film-quality x-ray images that are displayed on a video monitor in 2D or 3D stereo.

Digital Equipment Corp. 612
Marlboro, MA,
will spotlight the Real-Time Integrator, a powerful, icon-based software tool for rapid development and execution of test, control, and data acquisition applications.

BOOTH

ESL Inc. 1122
Sunnyvale, CA,
will present ViewPoint, a 500-megasample/second analog and digital signal acquisition, analysis, and playback device, and DATAFLOW, a continuous data stream processor offering the advantages of high throughput and true flexibility.

Evans & Sutherland 1101
Salt Lake City, UT
Literature will spotlight the firm's state-of-the-art image generation and display systems, such as the ESIG-3000, used by NASA for astronaut training since 1976.

Federal Highway Administration 605
Washington, DC,
will highlight the latest technologies for pavements, structures, safety, and traffic. Information about the Intelligent Vehicle-Highway Systems will be presented.

Federal Laboratory Consortium 702
Sequim, WA,
provides access to the technical expertise and unique facilities available in the federal laboratory system.

Fermi National Accelerator Laboratory 809
Batavia, IL
Fermilab's research employing the superconducting Tevatron, the world's most powerful particle accelerator, has led to advances in cryogenics and superconductivity, accelerators for medical applications, computers and software, fast electronics, and controls.

Ferrofluidics Corp. 628
Nashua, NH,
will display products based on proprietary magnetic fluid technology, including environmental seals, advanced materials processing systems, fluid bearings, and audio ferrofluids.

FLIR Systems Inc. 205
Portland, OR,
will display a radiometric thermal imaging system that provides the highest-available resolution, real-time image in a thermoelectrically cooled system.

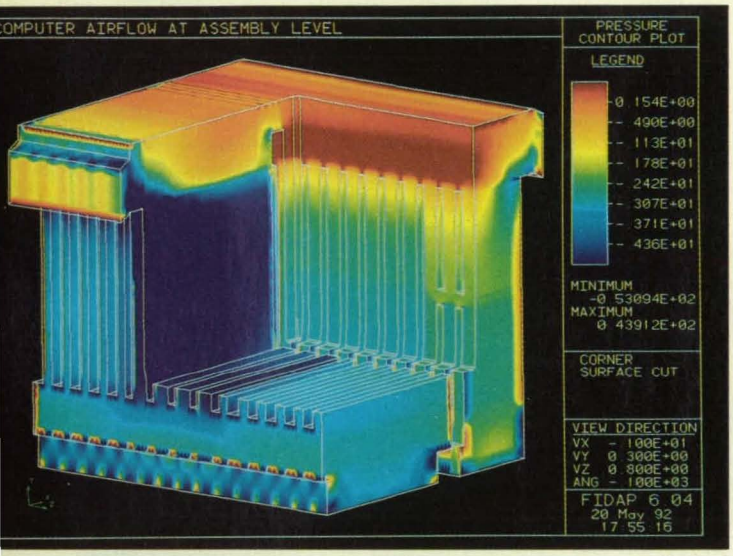
Fluid Dynamics International 308
Evanston, IL,
will demonstrate FIDAP general-purpose computational fluid dynamics software that handles incompressible and compressible flows and Newtonian and non-Newtonian fluids.

General Pneumatics Corp. 1101
Orange, NJ
Literature will describe custom-designed hydraulic and pneumatic valves, aspirators, cryostats, Stirling systems, and conversion and thermal management equipment.

GNB Corp. 1101
Hayward, CA
Literature will highlight vacuum equipment engineering and the firm's conventional and custom slit, gate, and poppet valves, as well as chambers, viewports, traps, baffles, and accessories.

Goddard Space Flight Center 530
Greenbelt, MD
Goddard's interactive exhibit will feature information technologies designed for biomedical applications and to assist the aging. A model of the EOS/AM spacecraft also will be displayed.

HEMCO Corp. 727
Independence, MO,
will exhibit the Unilab, a modular, self-contained room structure built to meet cleanroom, environmental control room, and laboratory work area requirements.



Fluid Dynamics International will demonstrate CFD software that simulates a variety of fluid flows for applications in aerospace, manufacturing, materials science, and other fields.

DATATAPE Inc. 208
Pasadena, CA,
will display high-environment, rotary digital and analog magnetic tape recording systems for military, aerospace, and commercial applications.

Defense Programs Technology Transfer: 1028
Lawrence Livermore National Laboratory, Los Alamos National Laboratory, and Sandia National Laboratories
This alliance of national labs and advanced manufacturing facilities seeks new ways for US industry to use the Defense Program's technical resources.

Department of Economic & Employment Development 604
Baltimore, MD,
will highlight resources for technology development in the State of Maryland including regional technology councils, the Maryland Venture Capital Trust, the University of Maryland, the Maryland Biotechnology Institute, Johns Hopkins University, the Christopher Columbus Center for Marine Research and Explorations, and the National Information Technology Center.

Department of Transportation 900
Washington, DC,
will feature the Aircraft Situation Display, a graphic depiction of current traffic and flight plans nationwide, and the Geographic Information System, a display and analysis of transportation-related spatial data.

DUAL Inc. 123
Arlington, VA,
will feature software engineering (including a real-time data system for NASA's Mission Control in Houston), systems integration products and services, hardware/software simulator engineering, and custom electronics manufacturing.

Edison Sensor Technology Center 827
Cleveland, OH
This exhibit will highlight the ESTC, which specializes in microsensor development, and the Center for Automation and Intelligent Systems Research, located with the ESTC at Case Western Reserve Univ., which provides R&D in machine, process, and data control and intelligent systems.

Electromechanical Systems Inc. 501
Corona, CA,
will display RF switching modules, power dividers, logic controllers, and switch matrix systems.

ERIM/IRIA 1101
Ann Arbor, MI
Literature will describe this DOD-supported information analysis center specializing in infrared, electro-optical, and microwave sensor and image processing systems for military applications.

BOOTH

Hewlett-Packard Company 1210
Rockville, MD

High Technology Systems Inc. 305
Troy, NY,
will feature base polyimide products for aerospace, aircraft, electronic, and automotive applications.

Hitachi Denshi America Ltd. 1220
Woodbury, NY,
will display a high-definition, rear-screen projection monitor, a low-light Haripon camera, and an HV-C10 compact color camera with three CCDs for high-resolution applications.

Hypertat Corp. 1106
St. Louis, MO,
will exhibit the All-Weather Portable Lab, a self-contained and expandable laboratory mounted on Caterpillar's innovative Mobil-Trac System. The lab is ideal for resource exploration, environmental monitoring, and remote terrain uses.

Idaho National Engineering Laboratory 805
Idaho Falls, ID,
will showcase nuclear reactor research, information technology, chemical sciences, waste treatment technology, materials research, biotechnology, applied engineering, and rapid prototyping.

IITRI Assurance Technology Center 802
Rome, NY,
offers consulting services and training programs in reliability, maintainability, and testability engineering, and operates the Reliability Analysis Center.

Impra Inc. 825
Tempe, AZ,
manufactures porous polytetrafluorethylene (PTFE) tubing, sheets, and rods. PTFE is a fully-fluorinated polymer with exceptional chemical and physical properties.

Industry-University Cooperative 1121
Research Center/University of Texas
Health Science Center at San Antonio
San Antonio, TX
The center serves as a liaison between commercial ventures and university researchers, facilitating technology transfer and communications.

BOOTH

Infolytica Corp. 810
Montreal, Quebec,
will feature MagNet software, which enables fast simulation and analysis of electromagnetic devices and includes modeling, solution, and post-processing.

Information Handling Services 122
Englewood, CO,
will display technical and regulatory information on CD-ROM, including full-text military specifications, industry standards, and vendor catalogs.

Inframetrics Inc. 914
North Billerica, MA,
will feature the models 760 and 740 high-performance thermal imaging radiometers as well as ThermaGRAM Version 5.0 and ThermoMonitor, the company's newest image processing software packages.

Innovation 128 Inc. 1019
Cambridge, MA
This consulting, information service, and technology transfer company based in the US and Europe offers specialists in such areas as advanced materials, polymers, and coatings.

INPEX/Intromark Inc. 600
Pittsburgh, PA
The Invention/New Product Exposition (INPEX) is an international event showcasing inventions, new products, and innovations to business and industry. Intromark, a marketing and licensing firm, works with new inventions.

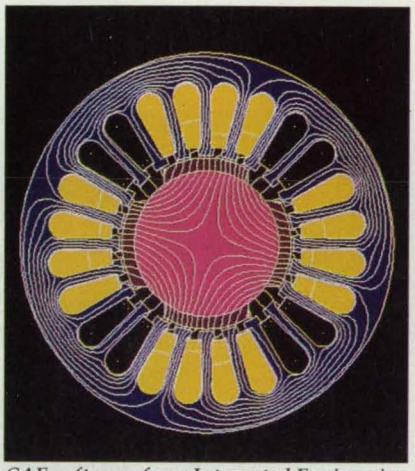
Institute of Environmental Sciences 1101
Mount Prospect, IL
The institute, a professional society of engineers and scientists established in 1956, will offer copies of its official journal.

Integrated Engineering Software 512
Winnipeg, Manitoba,
will present advanced CAE software packages for electromagnetic field analysis: ELECTRO (2D) and COULOMB (3D) electrostatic programs; and MAGNETO (2D), AMPERES (3D), and OERSTED (2D/RS time harmonic) magnetostatics software.

BOOTH

Integrated Sensors Inc. 713
Utica, NY,
will focus on development and prototype efforts in raw data sensor fusion concepts and applications and in lightweight, low-cost, flat-plate phased array antennas.

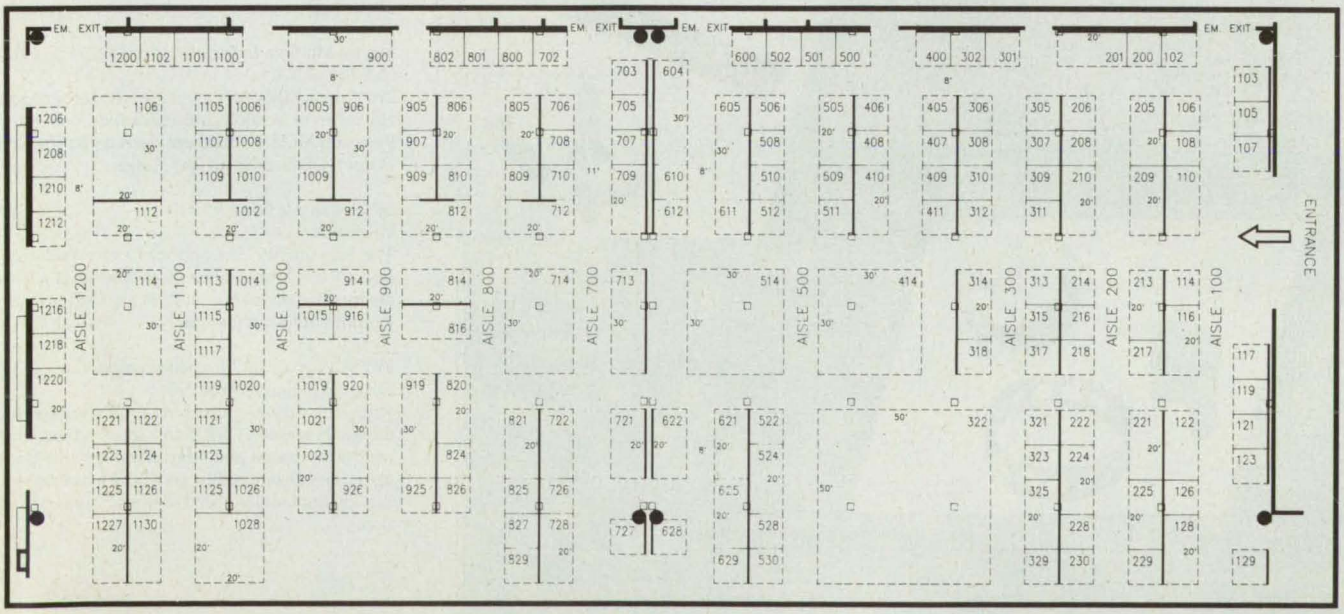
International Computers and 407
Telecommunications Inc.
Rockville, MD,
provides technical services in information management, telecommunications, logistics, engineering, and systems integration, and offers technical publication support services, developing the reports that appear in *NASA Tech Briefs*.



CAE software from Integrated Engineering is used here for 2D magnetic field analysis of a brushless motor.

International Environmental 1101
Institute/Westinghouse
Hanford Company
Richland, WA
A brochure will describe the institute's role as a resource center dedicated to environmental restoration, education, and the advancement of relevant technologies.

Exhibit Hall Floor Plan



BOOTH

Invention Machine Laboratory 1126
New York, NY
Invention Machine Lab and Imcorp will present software that solves complex engineering problems and predicts future technological developments.

Ithaco Inc. 1101
Ithaca, NY
Literature will highlight products and services for spacecraft attitude determination and control systems, such as Earth sensors, magnetometers, TORQRODs®, momentum/reaction wheels, and complete subsystems.

Ivy League Universities 217
This exhibit will spotlight hundreds of technologies developed at Cornell, Columbia, Dartmouth, Pennsylvania, and Yale that are available for commercial development.

BOOTH

Jet Propulsion Laboratory 522
Pasadena, CA

Johnson Space Center 321
Houston, TX,
will feature microstrip patch antenna sensors from RIMtech that can reliably measure ice thickness, water ethylene glycol, and slush conditions on airfoil surfaces and highway bridges. Also, DiGraphics Inc. will demonstrate graphics-based analysis software that displays causes and effects of system failures.

JW Lemmens Inc. 1101
St. Louis, MO
Literature will describe Grindo-Sonic, a system for nondestructive testing of materials' elastic properties.

BOOTH

Kennedy Space Center 325
Florida,
will show technologies with commercial potential including various sensors, computer software, and tube fittings.

Knowledge Express Data Systems 820
Wayne, PA,
will demonstrate Knowledge Express™, an innovative on-line computer search service to identify high-tech collaborative research and technology licensing opportunities with US government laboratories and universities.

Langley Research Center 524
Hampton, VA

Lawrence Berkeley Laboratory 1212
Berkeley, CA,
will highlight innovative, transferable technologies in such fields as biotechnology and life sciences, advanced materials, environment, energy, computing and communications, and transportation.

Lewis Research Center 323
Cleveland, OH,
will feature a structural health monitoring system for aging aircraft, manufacturing technology for complex-shape sapphire windows, diamond-like carbon samples, and PS-212, a high-temperature bearing material.

Lockheed Missiles & Space Company 806
Sunnyvale, CA,
will focus on NASA programs and advanced ceramic systems to meet the emerging technological requirements of the 21st century.

Machida Inc. 106
Orangeburg, NY,
will exhibit remote visual inspection equipment, flexible borescopes, lights sources, and video systems.

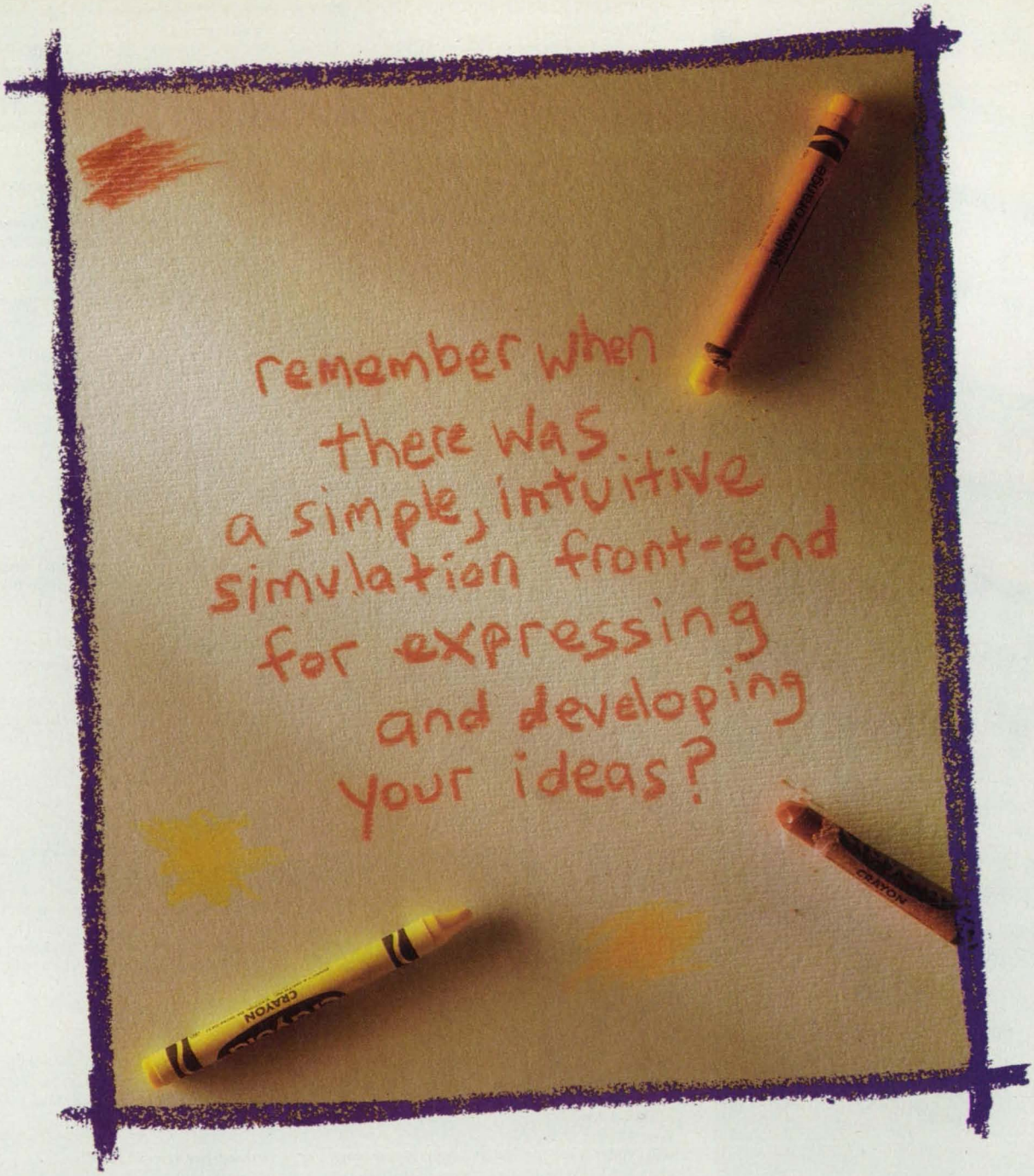
Marshall Space Flight Center 329
Alabama,
will showcase current projects in materials and processes, propulsion, structures, dynamics, astrophysics, and low gravity science.

Martin Marietta Electronics, 1227
Information & Missiles Group
Orlando, FL,
will demonstrate image processing technology for automatic object extraction to aid in environmental waste location, x-ray diagnostics, fingerprint identification, and optical character recognition.

Martin Marietta Energy Systems Inc. 1117
Oak Ridge, TN
The firm's Office of Technology Transfer negotiates terms of technology licenses and Cooperative Research And Development Agreements for three major DOE facilities in Oak Ridge.

McClellan Air Force Base 400
California
The Sacramento AirLogistics Center will show aircraft communications electronics and a nondestructive inspection system that scans entire aircraft without disassembly.

MCNC, Center for Microelectronics 119
Research Triangle Park, NC,
will display development and processing services for smart sensors, CMOS and smart power semiconductor design and fabrication, flip chip packaging, metallization, lithography, reactive ion etching, ion implantation, and chemical vapor deposition.



When you were a child, it wasn't easy putting your ideas into words. Fortunately you had crayons and paper so you could express and develop your thoughts visually.

Today there are still certain ideas that are best suited for graphic expression. That's why our Advanced Continuous Simulation Language (ACSL), the industry standard in simulation software, now offers a block diagram, graphical front-end. ACSL/Graphic Modeller combines the power, flexibility and execution speed of ACSL's code language with the simplicity and clarity of visual programming. This remarkable combination, with its ease of use, functionality and infinite extensibility, is the ideal solution for projects of every size.

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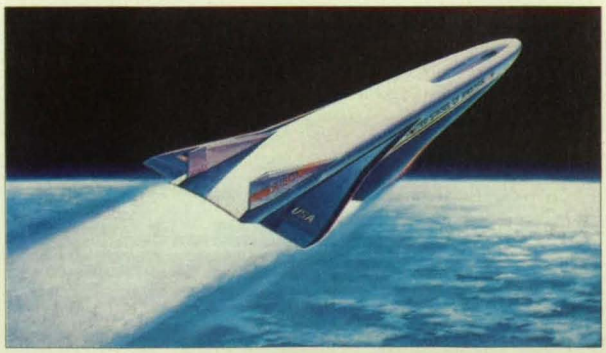
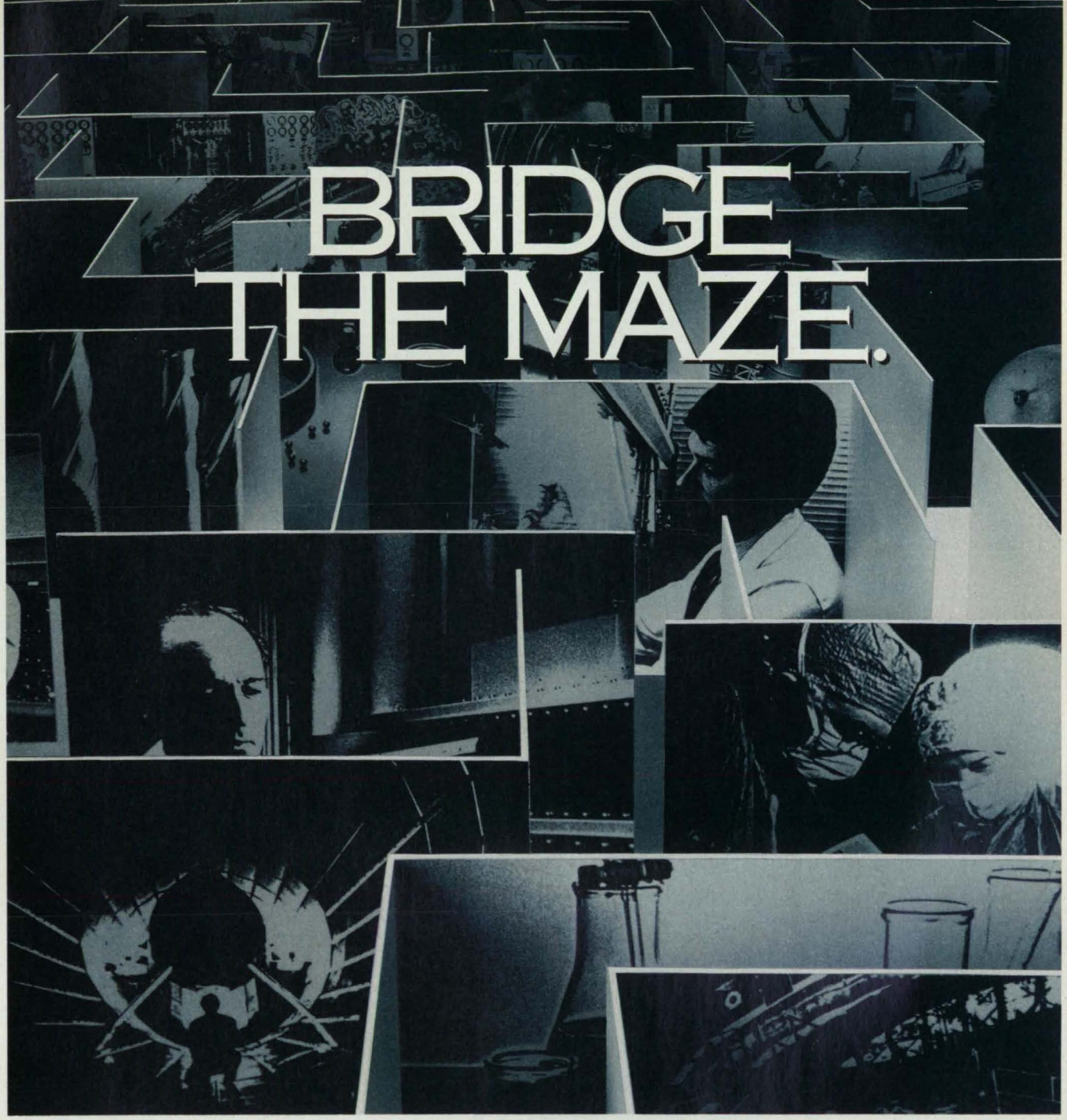
Mitchell and Gauthier
Associates, Inc.
The only real choice for simulations.

For More Information Circle No. 580

	BOOTH
MERP Enhanced Composites Willowdale, Ontario, will exhibit a low-power (100-watt), 7-80 kHz induction heater with microprocessor control and user-set parameters.	406
Micro Surface Morris, IL, will display engineered coatings for industry and describe available engineering consulting and services. Representatives will discuss the application of NASA- and university-developed technologies to wear- and friction-reduction problems.	1119
Mid-Atlantic Technology Applications Center Pittsburgh, PA, will demonstrate the Federal Laboratories Database, an easy-to-use package providing access to information on some 2000 federal laboratories, facilities, and centers.	925
Millitech Corp. South Deerfield, MA, will showcase millimeter and submillimeter wave components and subsystems for a wide range of applications including space-qualified versions deployed in NASA satellites.	713
Mitchell & Gauthier Associates Concord, MA, will feature the Advanced Continuous Simulation Language (ACSL), a complete environment for simulating and analyzing the behavior of nonlinear, dynamic systems. ACSL/Graphic Modeller, a new block diagram front end, adds the clarity of visual programming.	1125
Modular Instruments Inc. Malvern, PA, will exhibit Scroller Scope, a paperless strip chart recorder that displays up to eight waveforms on any VGA monitor. The screen can display from milliseconds to hours of data.	502
Moltech Corp. Stony Brook, NY, will display lasers, a computed tomography and microtomography system, nonlinear optical crystals, and standard optical parts and materials.	301
Morgantown Energy Technology Center Morgantown, WV, will present transfer opportunities in natural gas sources and recovery, coal gasification and cleanup, advanced fossil fuel combustion, and novel instrumentation and fluidized bed technologies.	707
Multitech Inc. West Chester, PA, will exhibit servo controllers, amplifiers, motors, precision X-Y positioning systems, industrial controllers, and computers.	1009
NASA Washington, DC NASA's "theater island" will highlight technologies developed for industrial use in such fields as materials, microsensors, and life sciences. The exhibit will feature a 20-foot video wall and models of the National Aero-Space Plane, the space shuttle, and space station Freedom.	322
NASA Center for AeroSpace Information Baltimore, MD, will demonstrate how NASA-generated technology has found its way into the private sector via commercial spinoffs. Technology transfer specialists will explain how the professional community can tap into NASA's vast storehouse of available technology.	714
NASA Centers for the Commercial Development of Space Washington, DC	1114
NASA Regional Technology Transfer Centers Washington, DC	920
NASA Scientific and Technical Information Program Washington, DC, provides a full line of products and services to help meet the scientific and technical information needs of researchers worldwide.	318
NASA Small Business Innovation Research Program Washington, DC, will display and demonstrate commercial products, processes, and services from participants' R&D projects. The program's 1992 Product Catalog will be available.	625
NASA Tech Briefs New York, NY	919
National Information Technology Center Rockville, MD, is a government-industry-academic partnership providing information technology brokerage, an experimental ISDN testbed, applied R&D and usability labs, and guided entrepreneurship, as well as publications, seminars, and training.	610
National Institute of Standards and Technology Gaithersburg, MD, will exhibit services that provide technical support and, in some cases, financial assistance, to US industry, especially to small and medium-size businesses.	621
National Institutes of Health Bethesda, MD The NIH Office of Technology Transfer assists the biomedical industry in commercializing leading edge scientific research conducted by the Public Health Service. Licensing portfolio specialists will be available to assist companies in identifying licensing or joint R&D opportunities.	116



NASA's "theater island" exhibit will include a 50-foot model of the National Aero-Space Plane, a hypersonic aircraft designed to take off and land at conventional airport runways.



ALL TOO OFTEN, THE UNCERTAINTIES AND BLIND ALLEYS OF THE RESEARCH PROCESS CAN HINDER THE DEVELOPMENT, GROWTH AND COMPETITIVENESS OF BUSINESSES.

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For More Information Circle No. 428

BOOTH

National Renewable Energy Laboratory 712
Golden, CO,
will spotlight R&D in photovoltaics, wind and solar thermal technologies, energy efficiency in buildings, solid detoxification of water, and biofuels.

National Technical Information Service 129
Springfield, VA
An agency of the US Dept. of Commerce, NTIS is the central source for the sale of government-sponsored research, development, and engineering reports and foreign technical reports.

BOOTH

National Technology Transfer Center 722
Wheeling, WV,
strives to strengthen US industrial competitiveness by ensuring rapid and productive access to marketable federal technologies and by promoting collaboration between companies and federal laboratories in the development and commercialization of technological products, processes, and services.

Naval Air Warfare Center Weapons Div. 816
China Lake, CA
This joint exhibit of four US Navy R&D, test and evaluation labs will highlight work in electronics, communications, chemicals, materials, optics, computers, plastics, composites, ceramics, fiber optics, imaging technology, sensors, lasers, and construction technology.

BOOTH

Naval Research Laboratory 410
Washington, DC,
will exhibit eight R&D programs available for licensing including analog VLSI neural network integrated circuits, pulsed laser deposition of biocompatible ceramics, and a fiber-optic biosensor system.

Naval Surface Warfare Center 801
Philadelphia, PA
The center provides RDT&E, fleet support, and in-service engineering for surface and undersea vehicle HME and propulsion systems, as well as logistics R&D in support of the maritime industry.

NERAC Inc. 511
Tolland, CT
This technology transfer center works in cooperation with NASA and other government agencies and sources worldwide to help US businesses compete more effectively by providing problem-solving services and technological assistance.

NOAA Satellite Applications Laboratory 1123
Washington, DC
The National Environmental Satellite, Data, and Information Service manages the nation's civil Earth-observing satellite systems as well as global national databases for meteorology, oceanography, geophysics, and solar-terrestrial sciences.

Nondestructive Testing Information 1101
Analysis Center
Austin, TX
NTIAC collects, reviews, and evaluates nondestructive testing, evaluation, and inspection technology, providing a broad array of information analysis services and products.

North Carolina State University 1101
Raleigh, NC
A brochure will describe the NASA Mars Mission Research Center at North Carolina State Univ. and North Carolina A&T State Univ.

Novespace 926
Paris, France,
will describe European technology transfer networks established around Novespace, and will feature various technology catalogs.

NSI Technology Services Corp./Division of 629
ManTech International Corp.
Alexandria, VA,
provides support services for engineering, design, fabrication, integration, test and evaluation of flight hardware, and conducts maintenance, operations, and systems engineering of research simulators and aircraft.

Numerical Algorithms Group 405
Downers Grove, IL,
will feature Fortran 90 technology plus the AXIOM system for symbolic algebra and visual mathematics. Applications in orbital mechanics, dynamics, chaos, and fractal geometry will be demonstrated.

NYMA Inc. 812
Greenbelt, MD,
manufactures a line of 386 and 486 PCs and provides systems integration, systems engineering, and programmatic support to the aerospace industry.

Oak Ridge National Laboratory 1014
Oak Ridge, TN
Operated by Martin Marietta Energy Systems for the US Department of Energy, the laboratory conducts R&D with an emphasis on working with industry and transferring technology.

BOOTH

Oklahoma Center for Integrated Design and Manufacturing 1101
Stillwater, OK
Literature will describe this technology consortium of three universities and industry, and identify its technology transfer target areas.

Oneida Research Services 411
Whiteboro, NY,
will introduce ORSolutions, a nationwide network of scientists and engineers with microelectronics expertise offering on-site support in TQM, glass to metal seal failure analysis, process efficiency enhancement, hermeticity evaluation, and SPC implementation.

Pacific Northwest Laboratory 709
Richland, WA,
will highlight ReOpt™, a database with information about remedial action technology derived from EPA, DOE, and industry sources. Also featured will be in situ vitrification, which uses high temperatures to convert contaminated soil and rocks into a stable glass and crystalline material, and a low signature vehicle that characterizes hazardous waste sites on steep and rough terrain.

Philtec Inc. 1216
Arnold, MD,
will exhibit fiber-optic displacement sensors for precision dynamic measurements in such applications as motion analysis of vibrating or rotating targets.

Photonic Systems Inc. 229
Melbourne, FL,
will display 1 and 4 GHz bandwidth, 1 MHz frequency resolution acousto-optic spectrum analyzers that provide instantaneous frequency measurement for signal analysis, spectroscopic, and test and measurement equipment applications.

Pittsburgh Energy Technology Center 703
Pittsburgh, PA,
will highlight examples of Cooperative Research And Development Agreements and licenses, as well as the broad range of industry interaction using the center's coal research expertise and facilities.

Pratt & Whitney—Waterjet Systems 209
Huntsville, AL,
will showcase Automated Robotic Maintenance Systems that use ultra-high-pressure water under precision robotic control to remove coatings (including plasma-sprayed), paints, and seals in an environmentally-sound, cost-effective manner.

BOOTH

Precision Filters Inc. 1113
Ithaca, NY,
will exhibit a line of fully-integrated data acquisition and conversion systems including high-density switch matrices, transducer amplifier/filters, anti-alias filters, and high-speed A/D converters.

Princeton Plasma Physics Lab 710
Princeton, NJ,
will showcase developments in magnetic systems, plasma processing of materials, x-ray laser technology, and plasma instrumentation and measurement.

Proto Manufacturing 311
Detroit, MI,
will exhibit highly-accurate automated x-ray diffraction systems for real-time measurement of residual and applied stress and nondestructive measurement of retained austenite.

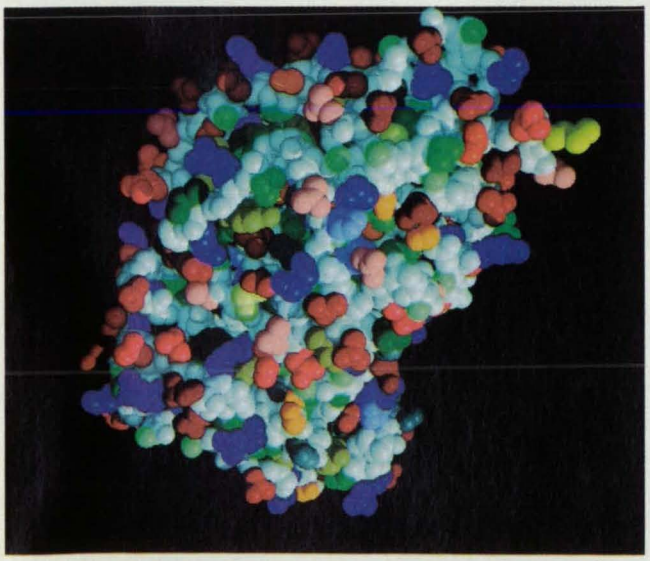
Ramtek Corp. 1101
San Jose, CA
Literature will describe TERRAIN, a software package for applying remotely sensed data in such fields as environmental studies, land use planning, natural resource management, mapping and cartography, reconnaissance, and surveillance.

Regain 1101
Columbia, MD
A brochure will describe new technology for manual wheelchairs that feature standing mobility, separate hand and traction wheels, and "forward only" for climbing ramps.

Rexham Industrial 705
Matthews, NC,
is a contract manufacturer specializing in precision coating and laminating of films, foils, papers, and fabrics.

Research Triangle Institute 315
Research Triangle Park, NC
NASA's Technology Applications Team at RTI works with NASA field centers, other federal agencies, and national associations to develop cooperative projects. This exhibit will feature the RTI-developed Spinoff Technology Application Retrieval System.

RGB Spectrum 108
Alameda, CA,
will feature Watchdog™, which displays up to 15 video sources in monochrome windows on a workstation. Watchdog accepts NTSC or PAL video signals and can be configured to accept infrared, radar, medical imaging, and other nonbroadcast video formats.



A "magic bullet" for cancer therapy: NIH researchers will describe a commercially promising immunotoxin designed to fight cancer, AIDS, and arthritis.

BOOTH

RG Hansen & Associates 218
Santa Barbara, CA,
will exhibit cryogenic systems and components for use in spectroscopy sample cooling, materials research, and detector cooling, as well as custom cryogenic systems for R&D.

Ribbon Technology 824
Gahanna, OH,
will present "Melt Overflow" direct casting technology that produces superalloys and intermetallics in the form of fiber, particulate, and strip or foil.

Sandia National Laboratories 1130
Albuquerque, NM,
will feature highlights of Sandia's 81 satellite and space probe payloads, laser power beaming to geosynchronous satellites, applications of virtual reality to space, and lunar rover concepts.

Satellite Data Systems 1101
Cleveland, MN
Literature will describe a system for the reception, viewing, and enhancement of weather satellite imagery.

Scientific Research Associates Inc. 1101
Glastonbury, CT
A brochure on the firm's MINT Navier-Stokes code will highlight code capability and provide simulation examples.

Small Parts Inc. 829
Miami Lakes, FL,
offers overnight delivery of 8000+ engineering findings. The company will exhibit various components, materials, and precision tools from their current catalog.

Sonic Perceptions Inc. 1021
Norwalk, CT,
will display a binaural head and analysis system for use in determining sound quality and measuring psychoacoustic properties of sound environments and sound or noise generators.

Sonoscan Inc. 102
Bensenville, IL,
will showcase acoustic microscopy equipment and services, nondestructive inspection of capacitors, resistors, plastic and ceramic integrated circuits, and advanced material characterization using high-frequency ultrasonic inspection techniques.

Southwall Technologies Inc. 1101
Palo Alto, CA
Literature will highlight Southwall's Electro-Optic Laboratory, which models, designs, and produces advanced thin film coatings on flexible and rigid substrates.

Space Age Technology Products Corp. 713
Chicago, IL,
will display fire- and heat-resistant paint coatings that suppress smoke, as well as fire- and heat-resistant fabrics, caulks, and caulk bricks.

Space News 313
Springfield, VA,
is a weekly newspaper dedicated to the politics, business, and technology of space, offering concise and timely coverage of space community developments.

Spire Corp. 1101
Bedford, MA
Literature describes products and services available in the fields of biomaterials, optoelectronics, and energy technologies including processing services for medical components, exotic semiconductor wafers, defense optical coatings, and photovoltaic manufacturing equipment.

BOOTH

Statistical Sciences Inc. 216
Seattle, WA,
will demonstrate S-PLUS, a flexible, interactive computing environment that provides a full-featured graphical data analysis system and an object-oriented data language.

Stennis Space Center 228
Mississippi

Stephens Analytical Inc. 317
Montreal, Quebec,
will exhibit the MCM hygrometers (trace moisture analyzers) for air and noncorrosive gases. They offer rapid response, accuracy, reliability, and an exclusive "push purge" diagnostic feature.

Strategic Defense Initiative Organization 230
Washington, DC
The SDIO's Office of Technology Applications will showcase spinoffs from SDI research and provide information about its technology transfer program.

Strategic Innovations Intl. 1101
Lake Wylie, SC
Broadening the Search For Clues To Product Commercialization will describe a proven method for identifying applications/markets for new materials, processes, or advanced technology.

Superconix Inc. 1101
St. Paul, MN
Literature will describe high-temperature superconducting materials such as substrates, crystals, rods, thick films, and melt-cast shapes, as well as low-temperature superconducting wire, magnets and commodity metals.

BOOTH

TAU Corp. 1101
Los Gatos, CA
Literature will highlight automated digital tracking and measurement systems for testing, surveillance, and inspection applications.

Technical Insights Inc. 409
Fort Lee, NJ,
identifies and monitors technical developments poised for near-term, explosive growth, analyzes emerging technological trends, and locates small, innovative companies likely to become technology giants.

Technology Access Report 302
San Rafael, CA,
offers monthly news, analysis, and opportunities in technology transfer, management, and commercialization through cooperation between industry, government, academia, and capital.

Technology Transfer Business 121
Vienna, VA,
is a quarterly magazine presenting business strategies in technology transfer for CEOs, directors of engineering and manufacturing, and other R&D professionals.

Technology Transfer Society 206
Indianapolis, IN
T^2S is dedicated to the development of professionals involved in technology transfer. Membership information, newsletters, journals, the membership directory, and society proceedings will be available.

BOOTH

Technology Utilization Foundation 1206
New York, NY,
will offer exhibiting opportunities at Technology 2003, the fourth national tech transfer conference and exhibition, to be held Dec. 7-9, 1993 in the Anaheim, CA convention center.

Techron 800
Elkhart, IN
Techron Power Products, a division of Crown International Inc., designs, manufactures, and markets products providing controlled current and voltage according to customer waveforms.

Tennessee Technology Foundation 1020
Knoxville, TN,
will exhibit advanced materials, neural networks, telecommunications, 3D image analysis, CFD modeling, high-volume data management, and performance analysis technologies.

Textron Specialty Materials 1124
Lowell, MA,
develops and manufactures high-strength, lightweight advanced composites and fire-protection materials for aerospace and industrial uses.

Thermal Sciences Company 1101
Houston, TX
Literature will describe methods for disposal and recovery of space debris. The firm is seeking investors or partners for related programs.

Thiokol Corp. 213
Brigham City, UT,
will highlight technologies developed in internal IR&D or DOD/NASA programs that show potential for commercialization, new propulsion concepts, or enhanced environmental processes.

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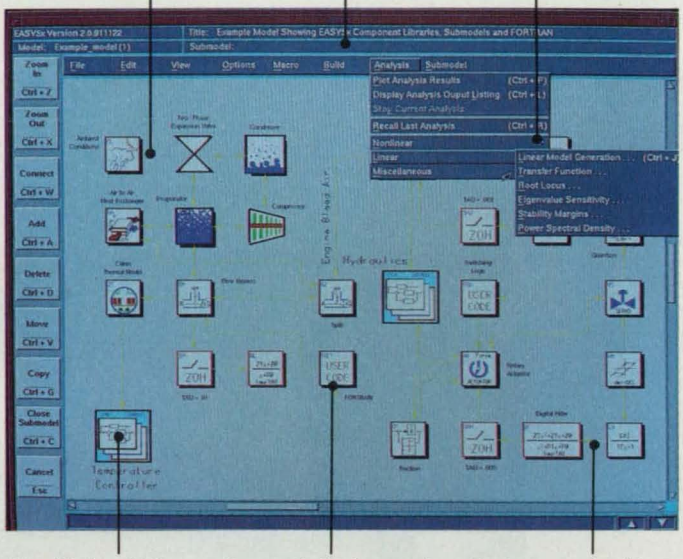
It gives you the power to visualize complex problems *the way you want to see them.*

Model documented via user-defined icons.

Motif®-based graphical user interface.

Wide variety of non-linear and linear analyses.



Nested "submodels" simplify large models.

User-supplied code integral to block diagram.

Continuous and multi-rate sampled-data components.

Almost all engineering analysis software works fairly well on nickle-and-dime problems. But when it comes to really difficult jobs, you run into a lot of limitations.

EASY5x is different.

It gives you the ability to look at big, complex problems. You can use it to model, simulate, and analyze virtually any type or size of dynamic system—even sampled-data control systems.

Easily build your own components.

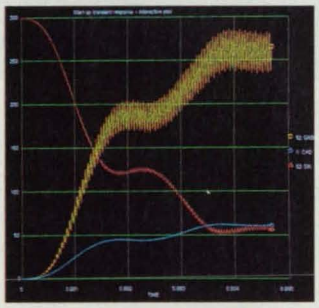
With EASY5x's open architecture, you can create your own application-specific components. Then store them, reuse them, and share them with other engineers.

Or, you can use any of our 195 modeling components.

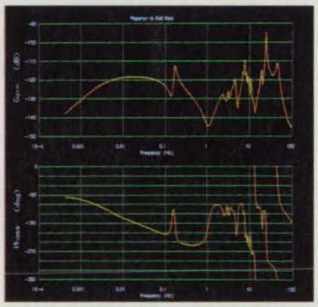
These standard "building blocks" will help you efficiently model dynamic effects or physical systems. Including tricky problems like friction and hysteresis, or two-phase refrigeration cycles.

Concentrate on the problem, not the software.

EASY5x gives you unparalleled flexibility. Yet it's easy to learn and simple to use.



Non-linear simulation results viewed interactively or off-line.



Frequency-response data displayed in Bode, Nichols, or Nyquist formats.

The X Window®-based graphical interface lets you work on engineering workstations without forcing you to learn special commands.

And when your problem becomes complex enough for speed to be important, EASY5x is an order of magnitude faster than our competitors' software. You can even run your analyses on a supercomputer.

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EASY5x wasn't created in an academic setting. It was developed, tested, and refined at Boeing, one of the world's leading aerospace companies.

Altogether, in fact, more than 2,700 Boeing engineers have used EASY5x. And the software has logged more than a million man-hours designing the airplanes you fly. But that's only the beginning.

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BOEING

For More Information Circle No. 497

Tiodize Company Inc. 110
Huntington Beach, CA,
will display all-graphite composite fastener products, self-lubricating composites, titanium anodizing, hard anodize with Teflon, anti-corrosion coatings, dry film and PTFE lubricants, Teflon coatings, and mold releases.

Turbomixer Corp. 826
Newark, DE,
will feature a new technology that dissolves gases into liquids at five times the current rate. It can be applied in aeration, air stripping, gasification, bioreactors, and pollution remediation processes.

United Magnet Technologies 1101
San Leandro, CA
Literature will illustrate the firm's design and fabrication of accelerator-beam-handling electromagnets, plasma fusion containment coils, inductors, and solenoids.

University of Dayton Research Institute 1026
Wright-Patterson Air Force Base, OH,
will describe human factors products and services available to engineers and designers to help them integrate HF principles into new systems and product designs.

Urethane 2000—A Urethane Company 713
Las Vegas, NV,
will discuss an ongoing project to design and construct self-contained residential, commercial, and industrial urethane structures with airborne, marine, and submarine capabilities.

USAF Manufacturing Technology Directorate 117
Dayton, OH,
will provide information on more than 100 ManTech projects with commercialization and transfer potential in electronics, integration technology, processing and fabrication, industrial base analysis, and concurrent engineering.

US Alcohol & Drug Testing 505
Rancho Cucamonga, CA,
will feature state-of-the-art alcohol breath testing and drug testing equipment for law enforcement, industry, and other organizations.

US Army Aeromedical Research Laboratory 500
Fort Rucker, AL,
will highlight research efforts to prevent or minimize health hazards in military operational environments and to enhance soldiers' performance. Focus areas include acoustics, vision, crew workload and stress, and life support technology.

US Army Armament Research, Development, and Engineering Center 1005
Picatinny Arsenal, NJ,
will showcase nondestructive inspection technologies including automated analysis of radiographs by artificial neural networks, high-speed lacquer positioning, depth measurements, and metal integrity determinations.

US Army Belvoir Research, Development and Engineering Center 1101
Fort Belvoir, VA
Literature will list technologies available for exclusive licenses or Cooperative Research And Development Agreements.

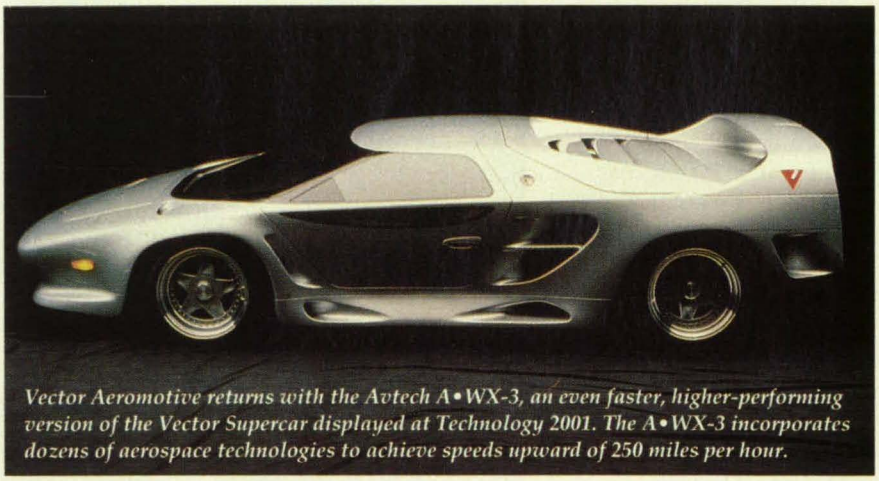
US Army Corps of Engineers 1112
Vicksburg, MS,
will highlight research and expertise at the Corps' four labs: the Waterways Experiment Station, the Cold Regions Research and Engineering Laboratory, the Construction Engineering Research Laboratory, and the Topographic Engineering Center.

US Army Electronics Technology and Devices Laboratory 310
Fort Monmouth, NJ,
will display electronics technology developed for Army systems with an emphasis on transfer to the private sector through cooperative and patent license agreements.

US Army Research Institute of Environmental Medicine 1101
Natick, MA
Literature will describe collaborative research opportunities in biomechanics, sports medicine, nutrition, and psychological, physiological, and chemical responses to the stresses of heat, cold, exercise, and high altitudes.

US Army Research Laboratory 225
Adelphi, MD,
will display new technologies in advanced computing and software, battlefield environment, electronics and power sources, sensors, materials, and more.

US Bureau of Mines 307
Washington, DC,
will highlight innovations relating to mining and minerals with technology transfer and cooperative research potential.



Vector Aeromotive returns with the Avtech A•WX-3, an even faster, higher-performing version of the Vector Supercar displayed at Technology 2001. The A•WX-3 incorporates dozens of aerospace technologies to achieve speeds upward of 250 miles per hour.

USDA Agricultural Research Service 103
Beltsville, MD,
will present computer-controlled equipment, expert systems, and bioprocess engineering systems for manufacturing value-added industrial and food products.

US Department of Energy 912
Washington, DC,
will showcase technology projects and achievements, technology transfer programs, and examples of successful commercializations.

US Department of Energy/Conservation & Renewable Energy 1012
Golden, CO,
will provide an overview of research activities in conservation and renewable energy, with an emphasis on building, utility, industrial, and transportation technologies.

US Department of Energy/Triodyne 201
Niles, IL,
will exhibit new technologies for environmental restoration and waste management.

US Environmental Protection Agency 1115
Cincinnati, OH,
will describe cooperative research and development opportunities available with the EPA.

US Marine Corps: Marine Corps Systems Command 1101
Quantico, VA
Literature will explain how the USMC is organized, its unique capabilities, and its plans to meet the challenges of the 21st century.

US Naval Academy 1101
Annapolis, MD
A booklet will highlight the academy's scientific and engineering expertise and research facilities.

Utility Development Corp. 1101
Livingston, NJ
A brochure will describe the firm's involvement in R&D of high-performance and cost-effective plastics, coatings, adhesives, inks, and composite materials.

Vector Aeromotive Corp. 414
Wilmington, CA
Gerald A. Wiegert, Vector's CEO and Chairman, will introduce his new design, the Avtech A•WX3, the ultimate aerospace-engineering supercar, and will display "black project" ideas for 21st century land, sea, and air vehicles. Be prepared for future shock.

Vermont Research Corp. 105
North Springfield, VT,
will feature high-performance data storage solutions including the RAIDstar® disk array, K2 solid state disk, and the ANSWER, an SMD to SCSI product that allows replacement of older disk drives with new technology.

Wacom Technology Corp. 1101
Vancouver, WA
Literature will describe graphics tablets featuring cordless, batteryless, pressure-sensitive pens and cursors that can serve as input devices for computer graphics, illustration, CAD, and desktop publishing.

Wolfram Research Inc. 214
Champagne, IL,
will demonstrate Mathematica®, a system for numerical, symbolic, and graphical computation used both as an interactive calculation tool and a programming language.

Editor's note: *The final and complete list of exhibitors and booth locations will be contained in the official program distributed on-site in the show registration area.*

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December 1-3, 1992
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- 60,000 square feet of exhibits showcasing cutting-edge innovations available for license or sale;
- The third annual Technology Transfer Awards Dinner, offering an unparalleled opportunity to network with government and industry executives in an elegant setting—the Hyatt Regency's Grand Ballroom.
- Top-level speakers including NASA Administrator Daniel Goldin, Maryland Senator Barbara Mikulski, Martin Marietta Chairman & CEO Norman Augustine, and Rockwell International COO Sam Iacobellis.

Technology 2002 Conference Program

Tuesday, Dec. 1

8:30 - 10:00 am	Keynote Address and Federal Technology Overview
10:00 - 11:45 am	Theme Panels: Cooperative R&D; Investment and Financing; Manufacturing Excellence
1:00 - 3:00 pm	National Critical Technologies (6 Concurrent Sessions)
1:30 - 3:30 pm	National Technology Initiative Workshops
3:30 - 5:30 pm	National Critical Technologies Concurrent Sessions

Wednesday, Dec. 2

9:00 - 9:45 am	Keynote Address: Aerospace Technology Transfer
10:00 am - 12:00 pm	National Critical Technologies Concurrent Sessions
1:00 - 3:00 pm	National Critical Technologies Concurrent Sessions
3:30 - 5:30 pm	University Tech Transfer Opportunities (Track #1) International Technology Forum (Track #2)
7:00 - 10:00 pm	Technology Transfer Awards Dinner

Thursday, Dec. 3

8:30 - 9:45 am	Concurrent Workshops: How To Do Business With The Government
10:00 am - 12:00 pm	National Critical Technologies Concurrent Sessions
1:00 - 3:00 pm	University Tech Transfer Opportunities (Track #1) International Technology Forum (Track #2)

Exhibition Hours

Dec. 1-2: 10:00 am - 6:00 pm; Dec. 3: 10:00 am - 5:00 pm

How To Register

Fax your completed preregistration form with credit card data to (212) 986-7864. To register by phone, call (800) 944-NASA.

Choose from four types of registrations:

- Complete registration—includes symposia, workshops, and exhibits for all three show days; tickets to the opening reception on Monday evening, Nov. 30 and to the Awards Dinner on Wednesday, Dec. 2; and a set of the official Technology 2002 proceedings;
- Three-Day Symposia/Exhibits—covers symposia, workshops, and exhibits Tuesday through Thursday;
- One-Day Symposia/Exhibits;
- Exhibits Only

	By 11/20	On-Site
Complete Registration	$240	$285
Three-Day Symposia/Exhibits	$150	$195
One-Day Symposia/Exhibits	$75	$95
Exhibits Only	— No Charge —	
Awards Dinner Only	$95	$105

On-Site Registration Hours: Nov. 30: 9:00 am - 5:00 pm;
Dec. 1-3: 7:00 am - 5:00 pm.
For information on hotel and car rental discounts, call Wendy Janiel at (800) 944-NASA.

Technology 2002 Preregistration Form

Use a separate form or photocopy for each registrant.

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check one:

- ❑ Complete Registration $240
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❑ bill my: ❑ AmEx ❑ VISA ❑ Mastercard

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Registrations and Awards Dinner reservations are transferable, and may be cancelled until November 20, 1992 subject to a $50 cancellation fee. After that date no cancellations will be accepted and no money refunded.

Fax to: Technology Utilization Foundation at (212) 986-7864

New Product Ideas

New Product Ideas are just a few of the many innovations described in this issue of *NASA Tech Briefs* and having promising commercial applications. Each is discussed further on the referenced page in the appropriate section in this issue. If you are interested in developing a product from these or other NASA innovations, you can receive further technical information by requesting the TSP referenced at the end of the full-length article or by writing the Technology Utilization Office of the sponsoring NASA center (see page 30). NASA's patent-licensing program to encourage commercial development is described on page 30.

Electro-Optical High-Voltage Sensors

New sensors for measuring high voltages (e.g., 10 to 20 kV) are being developed for use in automatically controlled power-distribution systems. The sensors are immune to electromagnetic noise at radio and lower frequencies and have greater range and are cheaper than conventional high-voltage sensors.
(See page 40)

Improved Capacitive Liquid Sensor

An improved capacitive sensor is used to detect the presence and/or measure the thickness of a layer of liquid. Features include interdigitated driving and sensing electrodes and a peripheral coplanar ground electrode that helps to reduce parasitic effects.
(See page 44)

Optical-Input, Optical-Output Morphological Processor

This processor would offer the speed of optical connection with other processors and the programmability of electronic internal logic circuitry. The processor would perform binary operations on the picture elements of a binary input image, yielding a processed binary output image.
(See page 52)

High-Performance, Semi-Interpenetrating Polymer Network

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(See page 85)

Improved Fluidized-Bed Reactor With Horizontal Staging

This reactor features multiple, horizontally arrayed stages. Several advantages are realized over the conventional designs, such as larger number of stages than in vertically stacked models, easier maintenance, and better heat retention, among others.
(See page 108)

Secure Container for Discarded Hypodermic Needles

A container designed for safe retention of discarded blood-collecting hypodermic needles and similar sharp objects in spacecraft may be adaptable by hospitals concerned with highly secure collection and disposal.
(See page 117)

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Conceptual drawing of a star tracking application.

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For More Information Circle No. 375

HOW YOU CAN BENEFIT FROM NASA's TECHNOLOGY UTILIZATION SERVICES

If you're a regular reader of TECH BRIEFS, then you're already making use of one of the low-and no-cost services provided by NASA's Technology Transfer Program. But a TECH BRIEFS subscription represents only a fraction of the technical information and applications/engineering services offered by this Program. In fact, when all of the components of NASA's Technology Transfer Network are considered, TECH BRIEFS represents the proverbial tip of the iceberg.

We've outlined below NASA's Technology Transfer Network—named the participants, described their services, and listed the individuals you can contact for more information relating to your specific needs. We encourage you to make use of the information, access, and applications services offered.

How You Can Access Technology Transfer Services At NASA Field Centers:

Technology Utilization Officers & Patent Counsels—Each NASA Field Center has a Technology Utilization Officer (TUO) and a Patent Counsel to facilitate technology transfer between NASA and the private sector.

If you need further information about new technologies presented in *NASA Tech Briefs*, request the Technical Support Package (TSP). If a TSP is not available, you can contact the Technology Utilization Officer at the NASA Field Center that sponsored the research. He can arrange for assistance in applying the technology by putting you in touch with the people who developed it. If you want information about the patent status of a technology or are interested in licensing a NASA invention, contact the Patent Counsel at the NASA Field Center that sponsored the research. Refer to the NASA reference number at the end of the Tech Brief.

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(202) 453-2424

How You Can Utilize **NASA's Regional Technology Transfer Centers (RTTCs)** — A nationwide network offering a broad range of technology transfer and commercialization services.

You can contact NASA's network of RTTCs for assistance in solving a specific technical problem or locating technology or markets that match your interests. The RTTCs are experienced in working with industry to define technology needs and acquire and commercialize applicable technology. User fees are charged for most services. **For more information, call 1-800-472-6785** and you will be connected to the RTTC in your geographical region (or you may call or write directly to the RTTC in your region).

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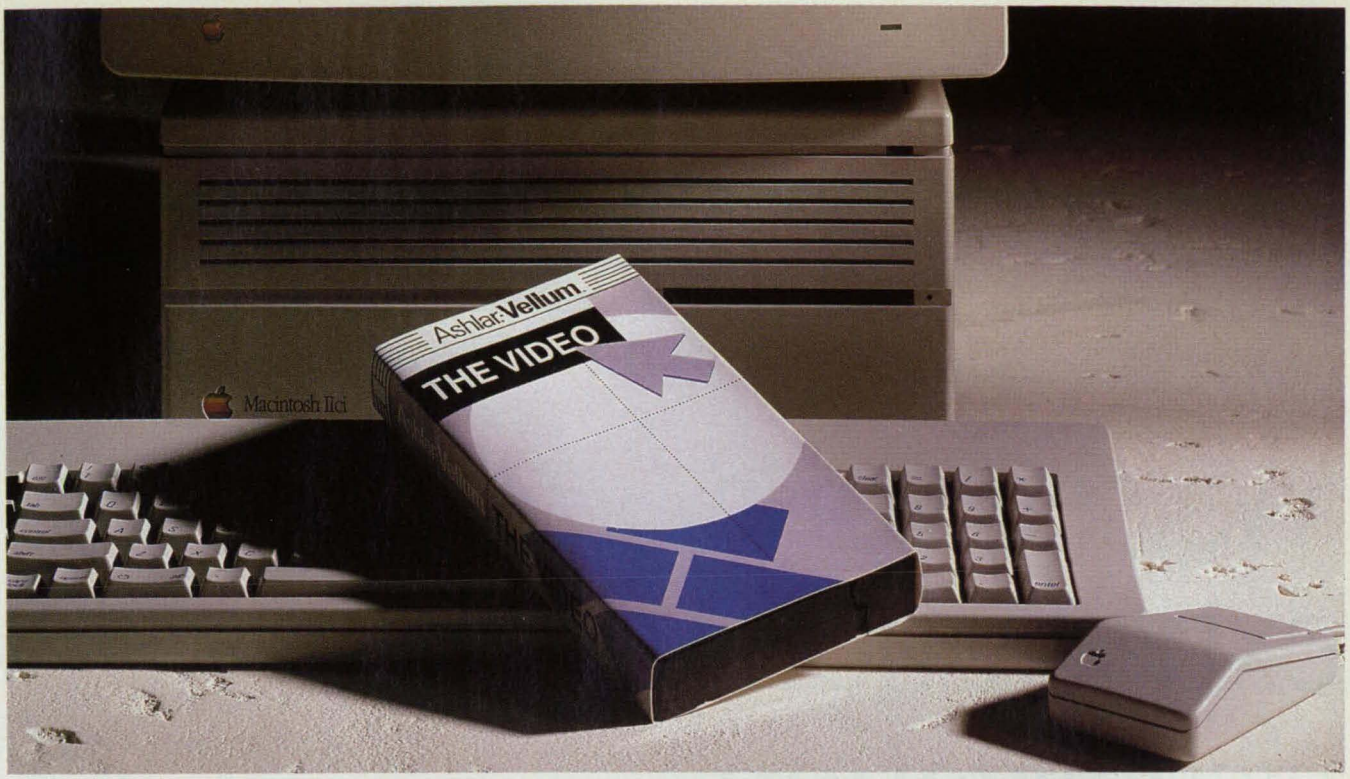
If you are interested in information, applications, research, training, and services relating to satellite and aerial data for Earth resources, contact NASA's transfer point for earth observing technology: **Technology Application Center, University of New Mexico, 2500 Yale Blvd. S.E., Suite 100, Albuquerque, NM 87131-6031; Dr. Stan Morain, Director (505) 277-3622.**

If you represent a public sector organization with a particular need, you can contact NASA's Application Team for technology matching and problem solving assistance. Staffed by professional engineers from a variety of disciplines, the Application Team works with public sector organizations to identify and solve critical problems with existing NASA technology. **Technology Application Team, Research Triangle Institute, P.O. Box 12194, Research Triangle Park, NC 27709; *Dr. Doris Rouse, Director,* (919) 541-6980**

A Shortcut To Software: **COSMIC®**—For software developed with NASA funding, contact COSMIC, NASA's Computer Software Management and Information Center. New and updated programs are announced in the Computer Programs section. COSMIC publishes an annual software catalog. For more information call or write: **COSMIC®**, 382 East Broad Street, Athens, GA 30602 *John A. Gibson, Director,* (706) 542-3265; FAX (706) 542-4807.

If You Have a Question..**NASA Center For AeroSpace Information** can answer questions about NASA's Technology Transfer Network and its services and documents. The CASI staff supplies documents and provides referrals. Call, write or use the feedback card in this issue to contact: **NASA Center For AeroSpace Information,** Technology Transfer Office, P.O. Box 8757, Baltimore, MD 21240-0757. *Walter M. Heiland, Manager,* (410) 859-5300, Ext. 245.



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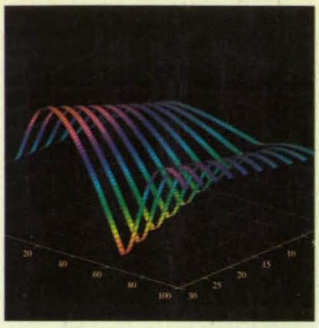
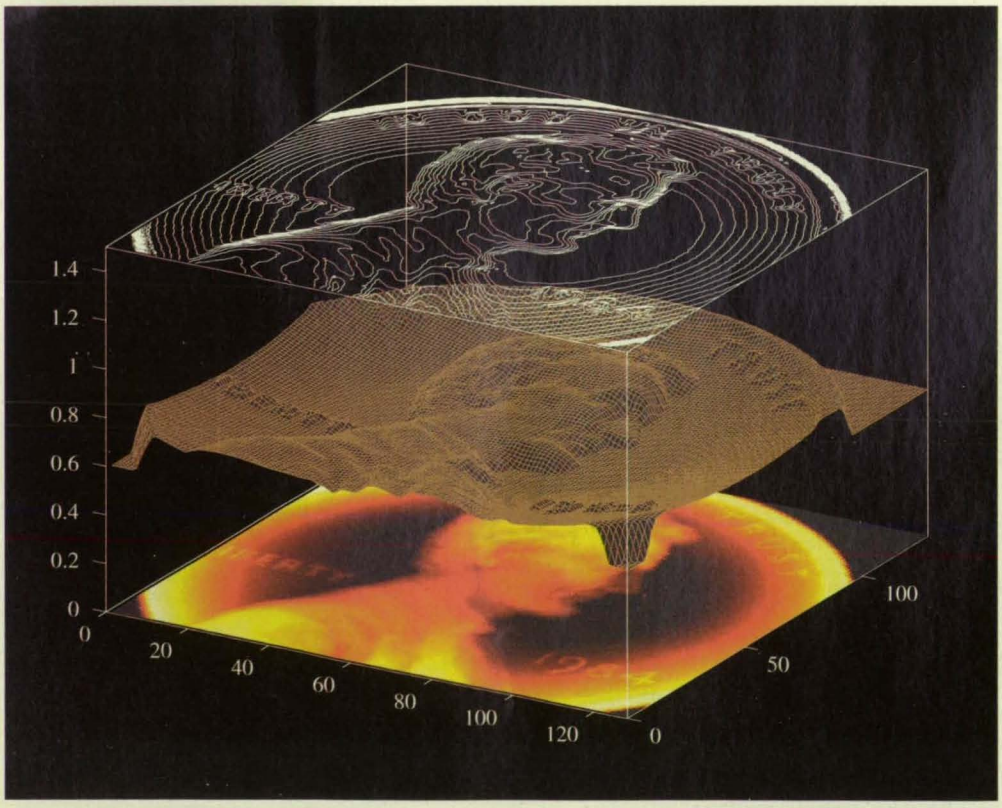
For More Information Circle No. 530

Frequency responses of a family of control systems, modeled, simulated and visualized in MATLAB 4.0.



We see your expectations of visualization and we raise them.



Three views of the surface height of a penny show user customizable object-oriented graphics in MATLAB 4.0. Data courtesy of NIST.

Combine advanced visualization with the powerful computation of MATLAB, and gain new insight into your most challenging problems.

The MathWorks introduces MATLAB 4.0

MATLAB 4.0 blends visualization techniques and numeric computation into a seamless interactive environment that redefines how you can solve complex problems. You can analyze data numerically and visually, simulate models and see the results immediately, or explore ideas and test them interactively.

More than meets the eye

MATLAB 4.0 provides you with an extensive library of built-in computational tools, combined with a powerful fourth-generation language.

It thereby offers the convenience of a pre-packaged application program and the extensibility and flexibility of a high-level language. Much easier to use than Fortran or C, MATLAB 4.0 yields tremendous gains in productivity and creativity.

New high-level functions enhance these gains—functions in areas ranging from advanced graphics to powerful sparse matrix support to integrated program development tools.

Add SIMULINK™ to MATLAB 4.0 and you can perform dynamic system simulation of nonlinear models in a graphical mouse-driven environment. And with specialized application toolboxes, you can tailor the MATLAB environment to address your specific needs.

We've devoted the next page to giving you a more complete picture.

MATLAB® 4.0

Picture the Power

Broadly applicable, widely used

Over 100,000 technical professionals use MATLAB in diverse applications areas, including signal processing, control engineering, chemistry, economic modeling, and data analysis. They use it as their primary analysis tool in industrial, academic, and government settings in over 50 countries.

Flexible & extensible

With the open system architecture of MATLAB, you can see the algorithms, edit them, and create your own to address specific needs. MATLAB provides multi-platform interoperability, so you can use your applications and data across platforms without modification. As a result, MATLAB has become the ideal way to create and communicate algorithms and ideas—a *lingua franca* for technical professionals.

Easy to use

MATLAB has always been powerful, yet easy to use—a fast and accurate number-cruncher, a high-level prototyping environment, and a complete programming language. MATLAB 4.0 adds many new features that make it more powerful and even easier to use.

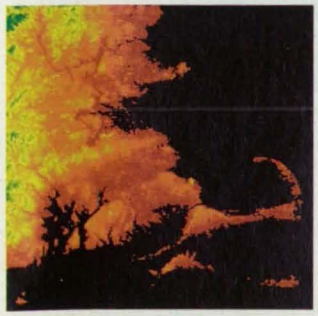
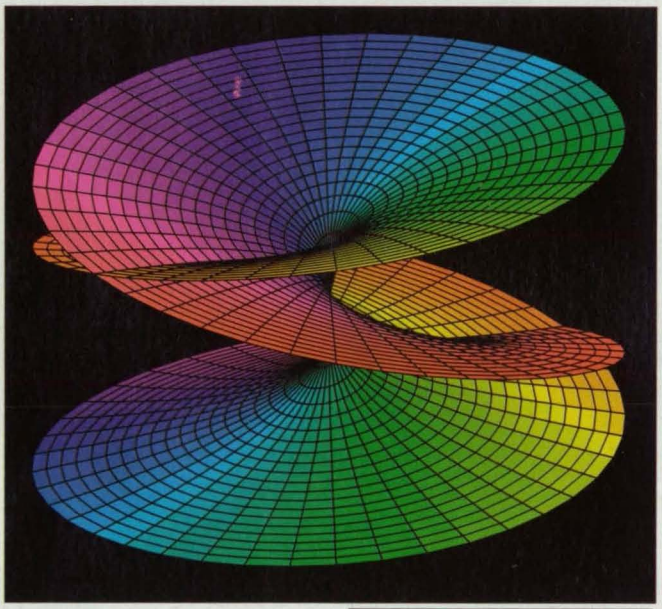


Image representation of Southeastern New England altitude data created in MATLAB 4.0. Data courtesy of NOAA.

New feature highlights

The most visible changes to MATLAB are graphical. NEW With our new object-oriented Handle Graphics™ system, you can customize virtually every conceivable attribute of your MATLAB plots.



Riemann surface of the complex cube root function shows the capability of MATLAB 4.0 for mathematical visualization

New graphics capabilities include:

- *3-D shaded color surface graphs*
- *3-D contour plots*
- *3-D data trajectories*
- *Image display*
- *Light sources*
- *Faceted and interpolated surface rendering, plus texture mapping*
- *Animation*
- *Color and black & white PostScript® output (Level 1 & Level 2)*

Beyond the visual

Other new features in MATLAB 4.0 include:

- ***Over 100 new functions***
- ***Graphical user interface controls***
  Add "widgets"—such as sliders, buttons, and menus—to create customized MATLAB graphical user interfaces easily.
- ***Enhanced file I/O***
  Import and export your data in any format.
- ***Sound output***
  Play data and functions as sound (SPARC only).
- ***Integrated debugging environment***
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  Call MATLAB from your C and Fortran programs as a computation engine.
- ***Faster interpreter and graphics***
  Draws graphics up to two times faster than MATLAB 3.5.
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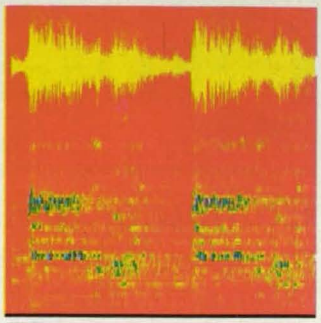
- ***New, expanded documentation***



Spectrogram of Handel's Hallelujah Chorus, *computed and displayed with MATLAB 4.0 and the Signal Processing Toolbox.*

Powerful, versatile toolboxes

Application toolboxes, designed and written in MATLAB by world-class experts in their fields, provide specialized solutions. They're based on MATLAB, and they combine pre-packaged functionality with an open systems approach that allows you to see the algorithms and to modify them to suit your needs.

The comprehensive MATLAB toolbox family includes:

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- *Robust-Control Design*
- *Mu-Analysis and Synthesis Design*
- *System Identification*
- *Neural Networks* NEW
- *Nonlinear Optimization*
- *Spline Analysis*
- *Chemometric Analysis*

MATLAB 4.0 is available now for Sun SPARCstations, and will soon ship for other standard MATLAB platforms including: 386/486 PCs, Macintosh, HP/Apollo, DECstation, VAX/VMS, IBM, Silicon Graphics, Convex, & Cray.

For more information, please call us at (508) 653-1415.

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Computer Simulation for Design of TWT's

Thermal and mechanical aspects are modeled mathematically in three-dimensional finite-element analysis.

Lewis Research Center, Cleveland, Ohio

A three-dimensional finite-element analytical technique facilitates the design and fabrication of traveling-wave-tube (TWT) slow-wave structures. Traveling-wave tubes are transmitter power amplifiers used in many space and terrestrial communications systems. The analytical technique includes the MARC finite-element code and enables designers to simulate the fabrication of components of a TWT. Simulated thermal loads like those encountered under various operating conditions can then be applied to a mathematical model of the TWT to predict temperature distributions, structural integrity, and failure limits.

In a typical traveling-wave tube, the radio-frequency (RF) signal to be amplified is launched onto a wire or tape that has been precisely wound into a helix. A beam of electrons traveling along the axis of the helix is velocity-modulated by the RF signal in such a way that the electrons become grouped into bunches that interact with the RF signal on the output section of the helix. The net effect of these interactions is an increase in the strength of the RF signal.

Figure 1 shows a partially assembled 20-GHz TWT helix structure. The helix is supported centrally in a metal sleeve by three dielectric support rods that are positioned at 120° intervals around the helix. The dielectric properties of the support-rod material must be selected so that the rods electrically insulate the RF signal on the helix from the body of the TWT (which is at ground potential). In addition, the material and the cross section of each rod must be chosen to minimize dielectric loading on the electromagnetic fields that surround the helix.

Highly pure, natural diamonds were used to make the rods in this application. The diamond rods not only support the helix but are also required to carry large thermal loads away from the tungsten helix tape; this, in turn, requires the maintenance of thermal contact between components at all times and at all operating temperatures. The new analytical technique provides for computer modeling that addresses such issues of structural integrity as those of contract pressures and contact areas.

Figure 2 displays an output from a three-dimensional computer analysis that describes the normal RF operating mode of a TWT. For computational economy, the model represents a 60° slice of the TWT, and is the smallest possible model that still fully describes the TWT geometry and structural loading through the application of rotational symmetry. This figure shows three 60° turns of the helix (representing the critical thermal region), half of a diamond support rod, and a 60° segment of

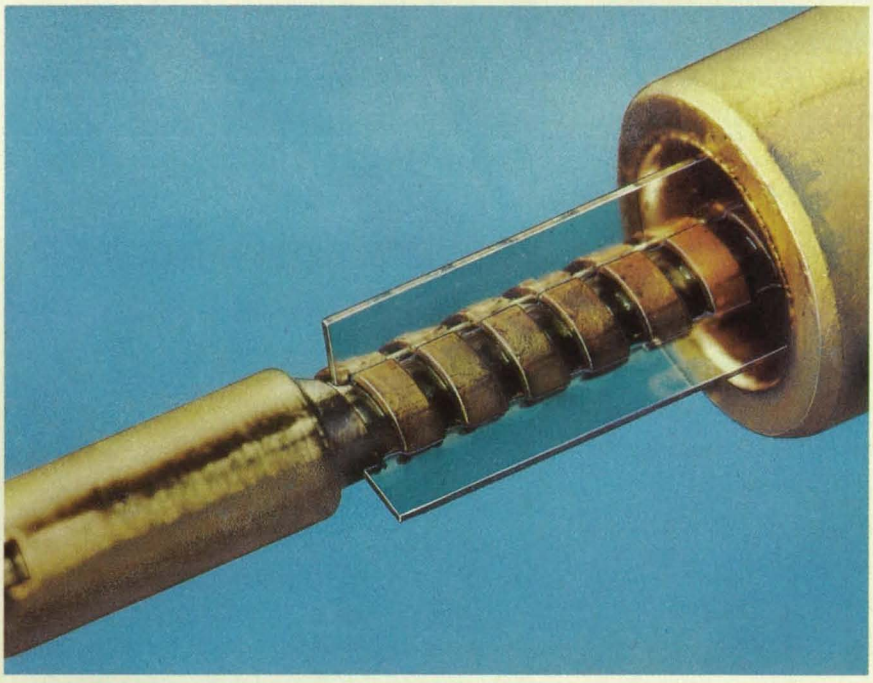

Figure 1. This **Partially Assembled Helix Structure** of a traveling-wave tube was analyzed by use of the technique described in the text.

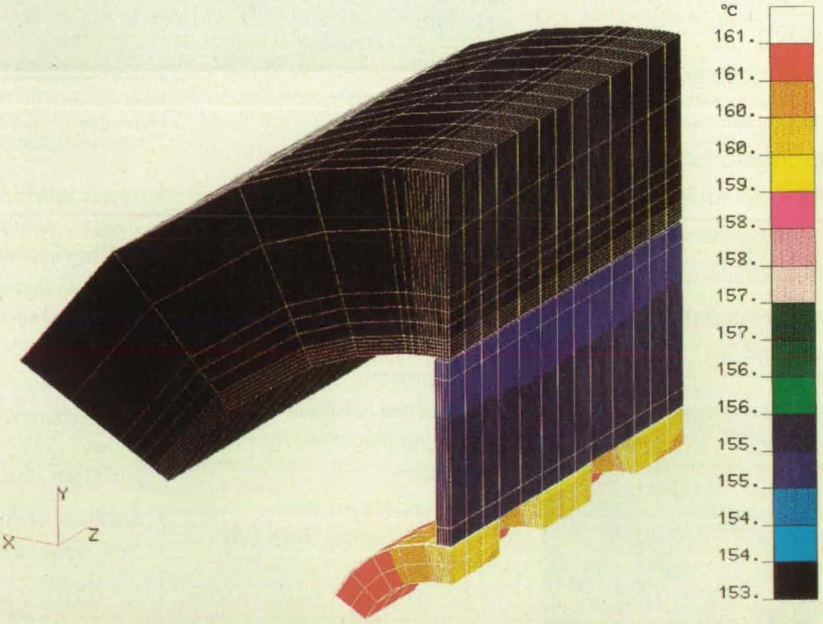

Figure 2. This **Distribution of Temperature** was computed on a three-turn, 60° segment of the helix structure shown in Figure 1.

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the outer sleeve. The temperature scale in this figure indicates that the highest temperatures within the assembly occur at those spots on the helix that are farthest away from a diamond support rod. The diamond support rod, being an excellent thermal conductor, exhibits an almost imperceptible temperature gradient across the radial dimension. The outer sleeve, used as a massive heat sink for the entire helix/rod assembly, has a spatially constant temperature. The results of this analysis were verified against actual experimental data.

The new technique can be used to perform thermal and mechanical analyses of a TWT designed with a variety of configurations, geometries, and materials. Such time-variant properties of the materials as creep can also be analyzed for their effects on the predicted performance and failure point of a TWT.

In using this three-dimensional computer analysis, a designer will be able to simulate the building and testing of a TWT, with consequent substantial saving of time and money. Moreover, computer simulation minimizes the number of tubes that must be produced under costly, iterative fabrication runs or for destructive testing. The new analytical capability provides a three-dimensional investigation of a three-dimensional structure, thus eliminating the uncertainties associated with two-dimensional approximations. Likewise, this analytical technique enables a detailed look into the operation of traveling-wave tubes to help improve performance for future communications systems.

This work was done by Karen F. Bartos, E. Brian Fite, Kurt A. Shalkhauser, and G. Richard Sharp of **Lewis Research Center**. *Further information may be found in NASA TP-3081 [N91-27436], "A Three-Dimensional Finite-Element Thermal/Mechanical Analytical Technique for High-Performance Traveling Wave Tubes."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
LEW-15374

Portable Computer Keyboard for Use With One Hand

The user need not be seated at a desk.

NASA's Jet Propulsion Laboratory, Pasadena, California

A data-entry device can be held in one hand and operated with five fingers. It contains seven keys (three for the thumb and one for each of the other remaining fingers). Letters, numbers, punctuation, and cursor commands are keyed into a computer by pressing the keys in various combinations.

The device, called a "data egg" for its original shape (see figure), can be used where a standard typewriter keyboard is unusable or unavailable — when the user is lying, walking, driving, or working on manual tasks, for example. It should be especially useful to handicapped or bedridden people who find it difficult or impossible to operate standard keyboards. In an alternative package (also in figure), the device resembles a personal pager ("beeper").

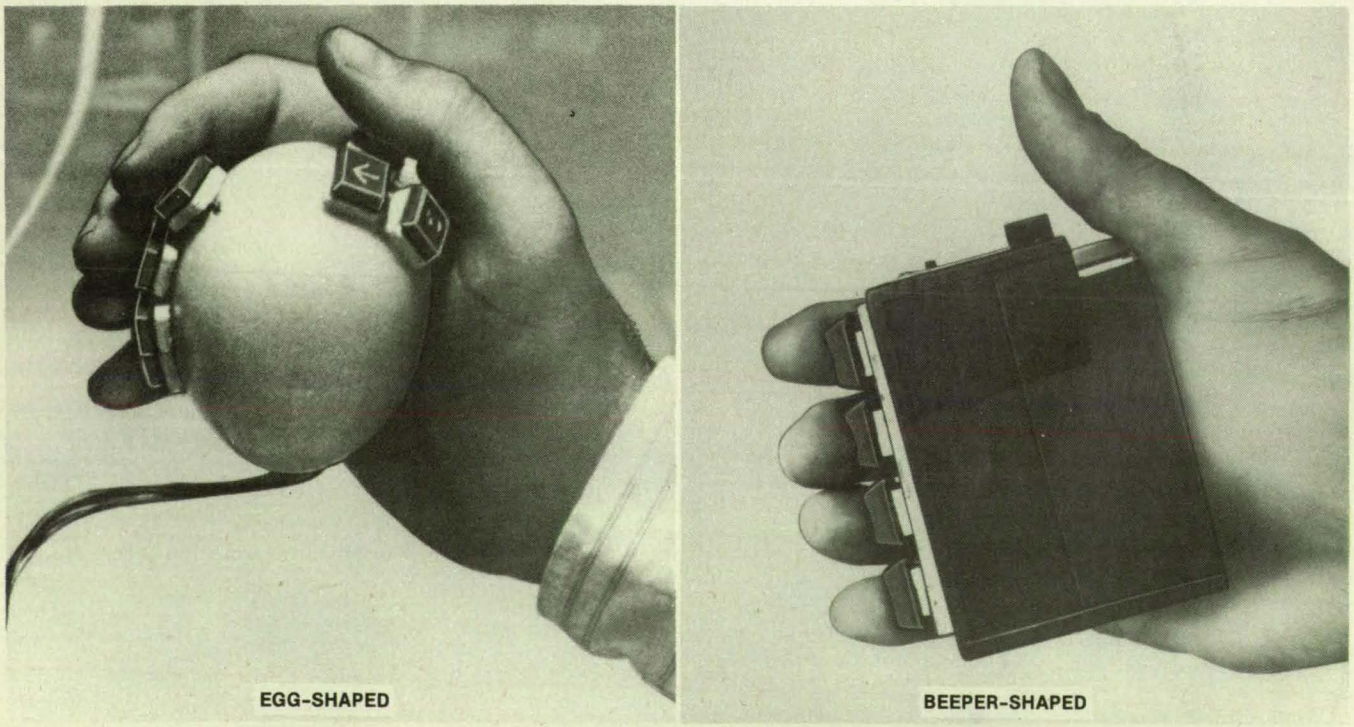
A prototype data egg contains a microprocessor and a 32-Kbyte memory. It can capture text and transmit it to a computer later on via a built-in serial port.

The concept can also be extended to a computer mouse. The mouse would be equipped with the seven keys. The user could then manipulate the mouse and simultaneously key in text with the same hand.

The key combinations are easy to learn. It can take less than an hour to memorize the alphabet, partly because the pressed-key configuration usually resembles some aspect of the character it represents. An experienced user can type about 30 words per minute without looking at the keys.

A bedridden user could operate a data egg in combination with a desktop computer and a commercial display device, called the Private Eye, that is worn a few centimeters in front of the user's eyes. This device displays a virtual image of the computer video monitor screen, which appears to be about 2 meters away.

This work was done by Gary L. Friedman of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 44 on the TSP Request Card.*
NPO-18231



EGG-SHAPED **BEEPER-SHAPED**

The **Handheld Keyboard** has only seven keys. The keyboard can be strapped to the hand. Both "egg" and "beeper" packages have been built.

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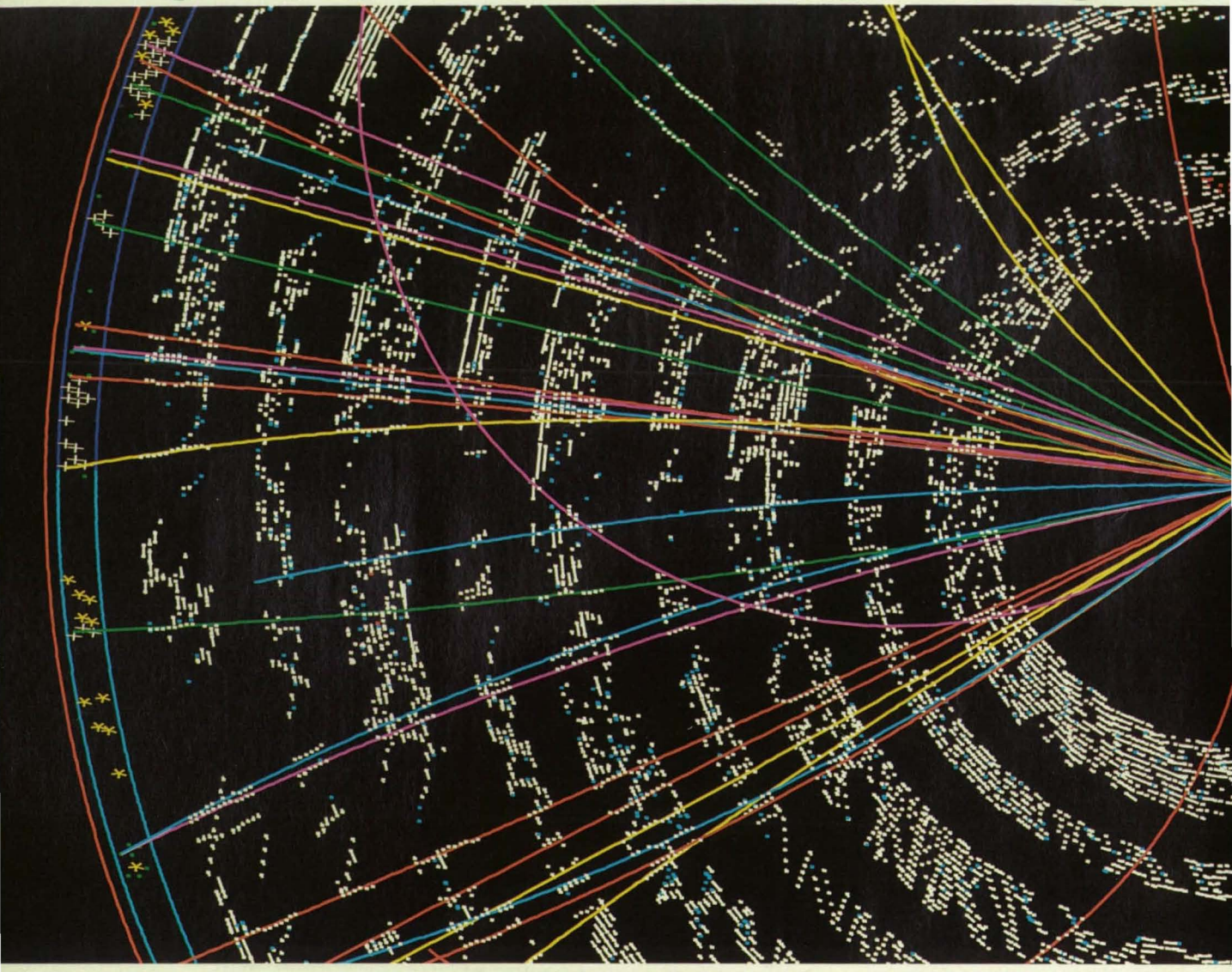
For More Information Circle No. 556

Highly parallel computing.



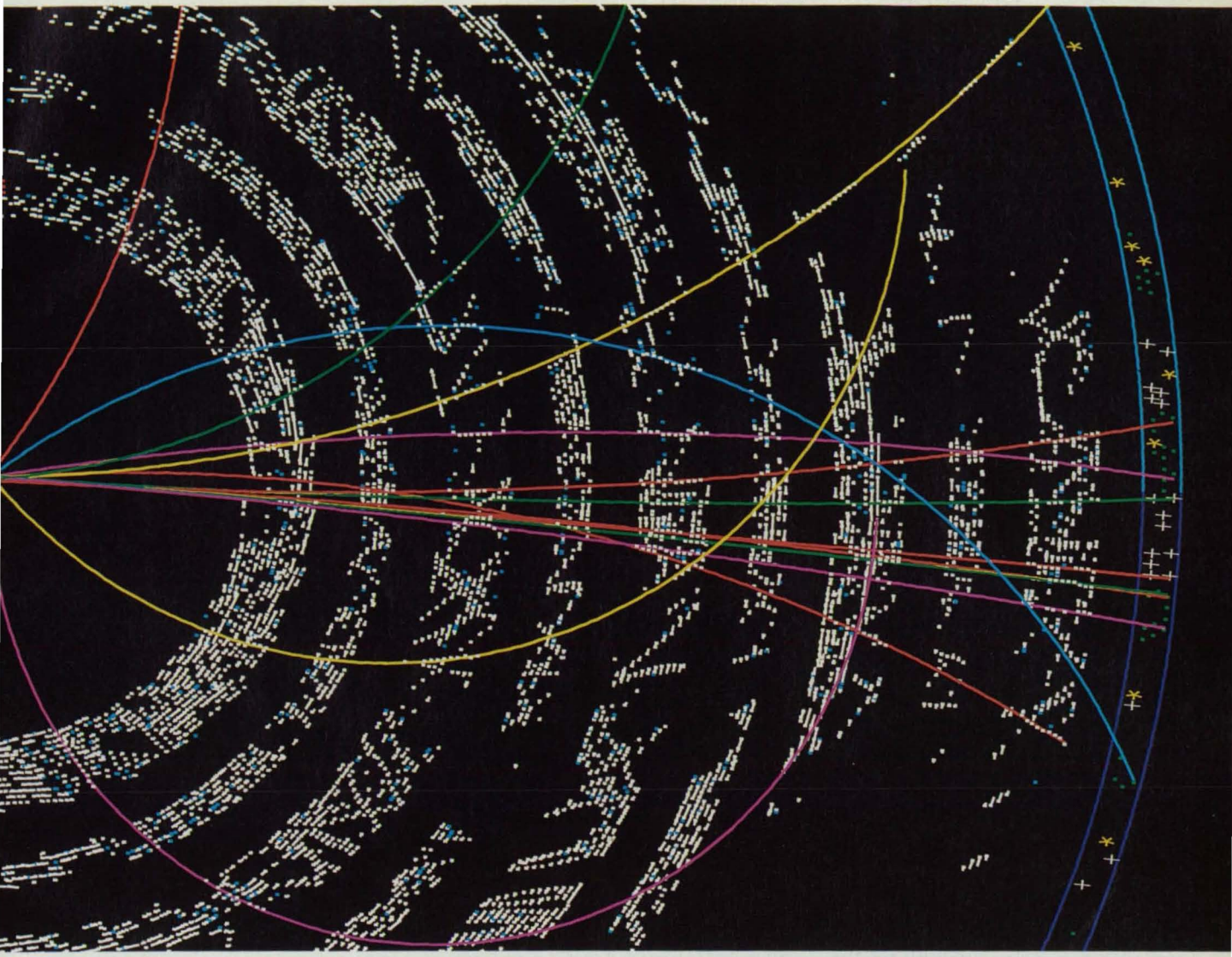
Fermilab is tapping a new

If there's one thing you can count on in science, it's that your data will increase exponentially but your funding won't.

The scientists at Fermi National Accelerator Laboratory (Fermilab) have encountered this problem in a very big way. The data Fermilab processes for subnuclear event reconstruction and modeling has reached 40 terabytes a year. And they've developed an innovative solution to meet their needs.

Instead of relying on supercomputers, Fermilab has distributed a significant part of the workload to clustered IBM RISC System/6000™ workstations. They've combined 108 of them, at latest count, in a LAN-connected

Computer reconstruction of proton/anti-proton collision at Fermilab.



source of power.

processor farm. This farm gives Fermilab a full 3,000 MIPS that can be dedicated to a single parallel processing application.

"The result," as Thomas Nash, Head of Computing at Fermilab puts it, "is better science." At a fraction of the cost of using supercomputers.

Many users are discovering the affordable, scalable power of clustered RISC System/6000 workstations.

The National Center for Supercomputing Applications in Champaign, Illinois, for example, runs superscalar applications on a cluster of seven RISC System/6000s. High performance and reliability are why they selected the RISC System/6000.

BP Exploration (Alaska), Inc. is achieving supercomputer throughput for their reservoir simulation applications by doing batch load balancing on a cluster of five RISC System/6000s. For their computers, software, systems integration and training in the use of batch clusters, they worked in alliance with IBM. We can help you, too – with consulting services, open systems integration and Business Partner software.

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Electro-Optical High-Voltage Sensors

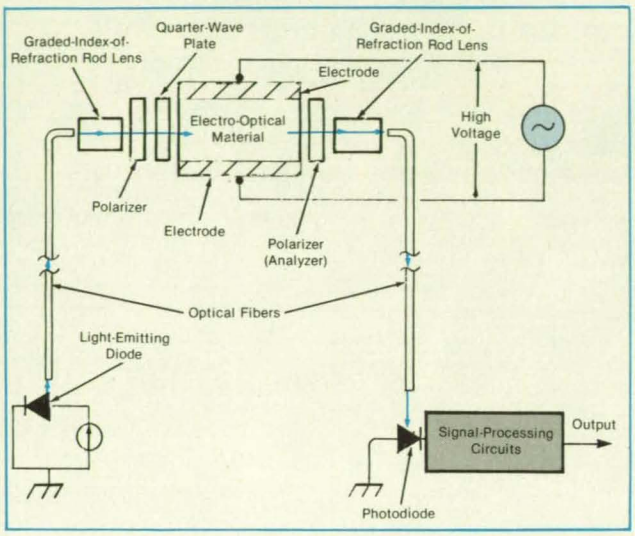
Features include relatively low cost, electrical isolation, and immunity from electromagnetic noise.

NASA's Jet Propulsion Laboratory, Pasadena, California

Electro-optical sensors for measuring high voltages (e.g., 10 to 20 kV) are being developed for use in automatically controlled power-distribution systems. A sensor of this type is connected to optoelectronic interrogating equipment by optical fibers (see figure). Because the sensitive material and the optical fibers are all dielectric, there is no problem in electrically isolating the interrogating circuitry from the high voltage, and there is no need for voltage dividers. The sensor signals transmitted along the fibers are immune to electromagnetic noise at radio and lower frequencies. In comparison with other high-voltage sensors, these have greater range and are cheaper.

The sensor is essentially a Pockels cell. It includes a slab of electro-optical material sandwiched between two electrodes that are connected to the high voltage to be measured. In this case, the electro-optical material is an electro-optically sensitive dye dispersed in an epoxy, as described in more detail in Bulk Electro-Optical Polymer Component" (NPO-18207) in a later section of this issue. The polymer slab used in the sensor prototype, was cured in a cuvette and later transferred in its solid state to the sensor housing.

The interrogating light is generated by a light-emitting diode, and transmitted to the cell along one of two optical fibers. The light emerging from this fiber is collimated by a graded-index rod lens, then passes through a polarizer and a quarter-wave plate into the cell. In the cell, the polarization of the light is altered by the electro-optical effect, which is approximately proportional to the voltage between the electrodes. The light emerging from the cell passes through a second polarizer (analyzer), is focused by a second rod lens into another optical fiber, and travels along that fiber to a PIN photodiode.



The **Electro-Optical Effect** in the sensor cell alters the polarization of light transmitted through it. The response of this sensor is a nearly linear function of voltage up to well beyond the breakdown voltage of the cell.

Sensors of this type are expected to respond nearly linearly from the minimum detectable potential up to potentials of the order of 1 MV. Consequently, the maximum operating potential will likely be limited by dielectric breakdown, which would occur well below 1 MV in typical designs contemplated thus far. An experimental sensor was tested at 7.96 kV (rms) and is believed to have a breakdown voltage of slightly more than the 54 kV peak (corresponding to 38 kV rms) used in fabricating it. For demonstration purposes, it should be safe to operate the sensor at 10 to 20 kV, provided that it is connected in series with a large current-limiting resistor.

This work was done by Allan Gottsche and Alan R. Johnston of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 98 on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Edward Ansell
Director of Patents and Licensing
Mail Stop 305-6
California Institute of Technology
1201 East California Boulevard
Pasadena, CA 91125

Refer to NPO-18311, volume and number of this NASA Tech Briefs *issue, and the page number.*

Compact Spare-Row Decoder for Computer Memory

Commercial integrated circuits are used.

Goddard Space Flight Center, Greenbelt, Maryland

A spare-row memory-address-decoder circuit can be commanded to address a ninth row in a computer memory instead of addressing one of eight others that it would address normally. Variants of this circuit could be used to construct small, highly reliable computers. The initial intended applications include the computers in the Hitchhiker Central Unit (a Space Shuttle payload) and an embedded computer on the Cassini spacecraft. The concept of the circuit is applicable to most flight computer systems. It has also been proposed to incorporate a triple-modular redundant version on an application-specific integrated circuit.

The spare-row decoder, which is made of standard radiation-hardened spacecraft integrated circuits, offers advantages of compactness, efficiency, and performance over error-detection-and-correction (EDAC) subsystems: In a system equipped with EDAC, a failure results in diminished performance. The spare-row decoder requires only 12.5 percent memory overhead, whereas an EDAC subsystem requires 37.5 percent memory overhead in a 16-bit memory system. Furthermore, a memory system equipped with a spare-row decoder requires less glue logic and exhibits greater throughput than does one equipped with EDAC.

The spare-row decoder receives a 3-bit memory address signal [$A(i)$, $A(i+1)$, $A(i+2)$]. In normal operation (when the spare row is not to be used), the decoder responds by asserting a signal on one of the eight lines (RAM0⋆ through RAM7⋆) to select the corresponding one of the first eight rows of memory (see figure).

By sending a 3-bit address signal ($D0$, $D1$, $D2$) to the decoder, the computer can designate one of the first eight rows of memory to be replaced by the spare row. If one of two decoder-enabling signals ($EN1$ or $EN2$⋆) is also received by the decoder, then whenever the incoming address [$A(i)$, $A(i+1)$, $A(i+2)$] is that of the row to be replaced ($D0$, $D1$, $D2$), the decoder

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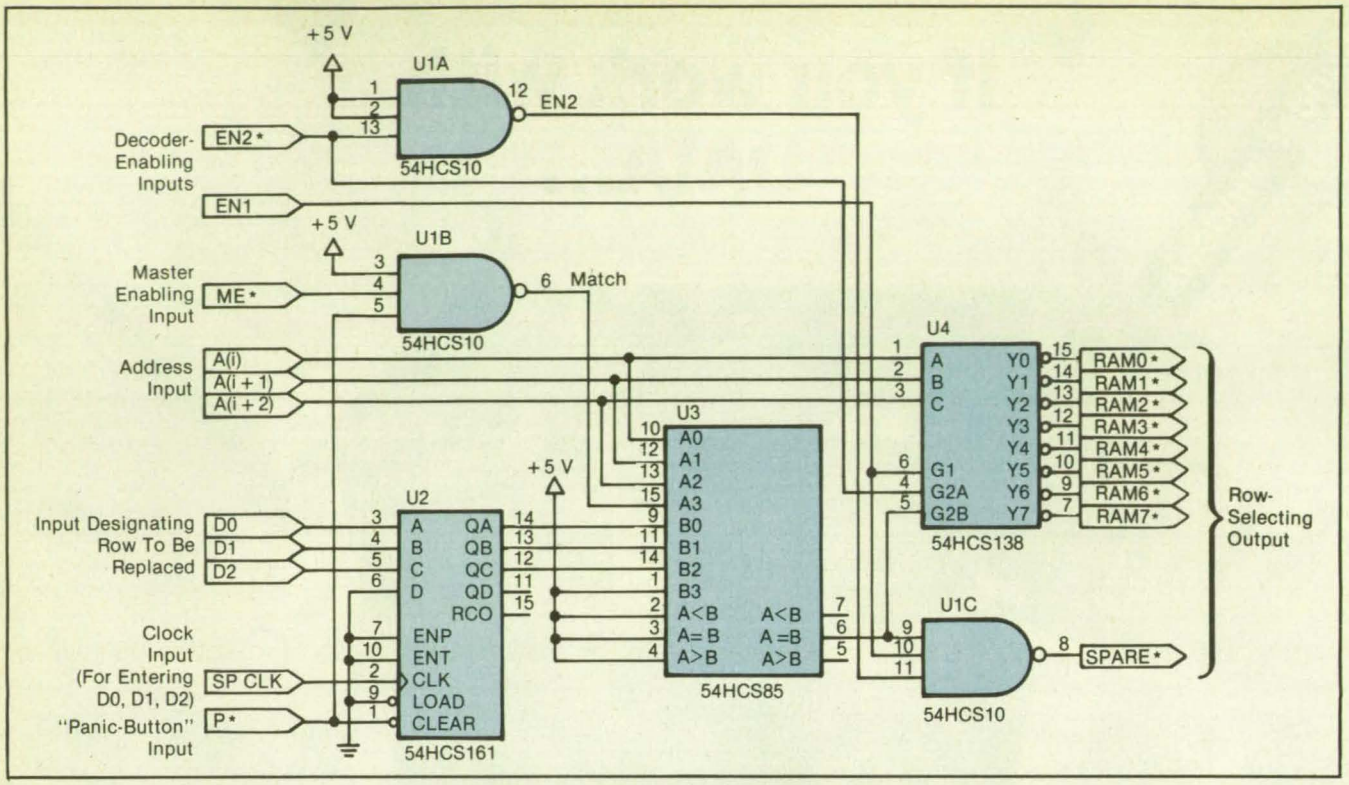

The **Spare-Row Decoder** selects the spare row of memory instead of one of the other rows, in which a defect has been discovered.

does not select one of the first eight rows but instead puts out the signal SPARE* on a ninth line to select the spare ninth row of memory.

There is a third decoder-enabling line, called "*P**" or the "panic-button" line. When *P** is asserted, the decoder automatically replaces row 0 with the spare row. This feature is used when the computer cannot "boot up" because of a failure in row 0. The *P** signal is activated simply by a hardware monitor.

This work was done by Richard B. Katz, Glenn P. Rakow, Thomas C. Bickler, and Rod Barto of **Goddard Space Flight Center**. *No further documentation is available. GSC-13481*

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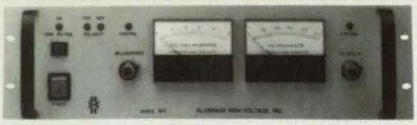

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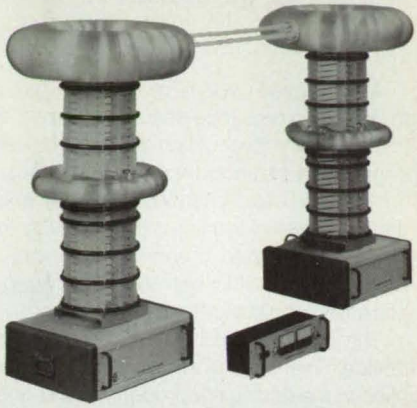

The PG Series includes open-stack models from 0 to 100 kV up to 0 to 400 kV with power capabilities of 500 or 1000 W. Normal ripple is 0.1% of rated voltage at full load. A special low-ripple version, the PG-LR Series, is available with ripple typically below 5 V p-p at rated voltage. Power is reduced to 250 or 500 W. The PG-LR Series consists of a high voltage multiplier and a low-pass filter stack in parallel, together with a remote control unit. The standard PG Series consists of only a multiplier stack and remote control unit.

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Improved Capacitive Liquid Sensor

A coplanar ground electrode reduces parasitic capacitive effects.

John F. Kennedy Space Center, Florida

An improved capacitive sensor is used to detect the presence and/or measure the thickness of a layer of liquid. The electrical impedance or admittance of the sensor is measured at a prescribed frequency, and the thickness of the liquid is inferred from the predetermined theoretical or experimental relationship between the impedance (or admittance) and thickness.

The sensor is basically a three-terminal device: The driving ac signal, v_D, is applied to the driving electrode, which is one of two interdigitating electrodes made of parallel strips of metal. The readout voltage, v_R, is induced on the other electrode (the sensing electrode) by capacitive coupling through the liquid and through the dielectric materials of the sensor structure (see Figure 1). The two electrodes are separated from a ground plane (the third electrode) by an insulating substrate of thickness d_s, which is much smaller than the width, $\lambda/4$, of each metal electrode strip.

The electrodes and substrate are covered by an insulating base layer of thickness d_b, which is also much less than $\lambda/4$. The center-to-center distance between adjacent electrode strips is $\lambda/2$. The outermost parallel strips belong to the driving electrode, and a wider electrode strip around the periphery of the electrode area in the electrode plane is connected to the ground plane. The thickness of the liquid is d_w and can be maintained at this value by a glass plate supported by metal shims around the edge.

Figure 2 presents schematic diagrams of the lumped-parameter equivalent circuit of the sensor. The capacitance C_p represents that part of the capacitive coupling between the driven electrode and the ground plane that is attributable to conduction through the liquid and capacitive coupling from the liquid through the base layer to the outer grounded electrode strip. (There is presumed to be no capacitive coupling through the liquid because the typical driving frequency of 1 MHz is much less than the dielectric-relaxation frequency of the liquid, and so the liquid acts essentially as a purely resistive medium.) C_p dominates the response of the sensor to the liquid and helps to stabilize the capacitance of the device, reducing parasitic capacitive effects.

The bottom part of Figure 2 shows the system for measuring the coupling admittance of the sensor. Provided that the impedance of the ammeter is much less than the capacitive reactance of C_s, one can neglect v_R and thereby simplify the computation of the coupling admittance. The coupling admittance can be decomposed into real and imaginary parts that depend on the various resistance and capacitive circuit elements and, therefore, on the thickness of the liquid.

This capacitive sensor is patent-pending because it is the first to utilize the ground plane as a "shunting" electrode. The shunt acts to improve the sensitivity of a capacitive sensor to changes in the dielectric properties of the liquid by a order of magnitude in the radio-frequency range. It is, therefore, now possible to detect dielectric relaxations that previously required measurement frequencies in the gigahertz range.

The shunting sensor can be used to measure the composition of a liquid if its thickness is held constant. When the sensor is fabricated into the wall of a pipe through which the liquid flows, the changes in the dielectric properties can be directly related to changes in composition. The sensor has been successfully evaluated in commercial production plants to characterize emulsions, slurries, and solutions. The system is less expensive than infrared, microwave, or refractive-index systems for on-line analytical measurement.

This work was done by Francis A. Waldman of Axiomatics Corp. for **Kennedy Space Center**. *For further information, Circle 8 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Kennedy Space Center *[see page 30].* *Refer to KSC-11541.*

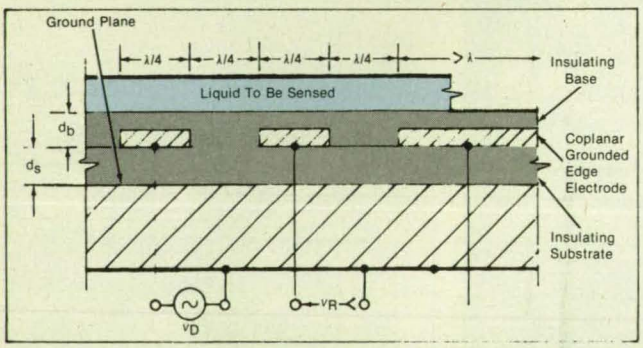

Figure 1. The **Improved Capacitive Liquid Sensor** features interdigitated driving and sensing electrodes and a peripheral coplanar ground electrode that helps to reduce parasitic effects.

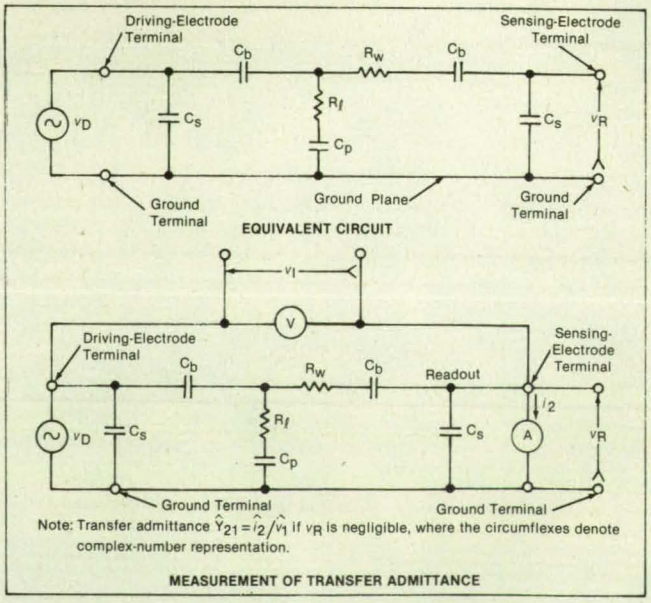

Figure 2. These **Equivalent Circuits** emphasize selected characteristics of the improved capacitive liquid sensor.

$Si_{1-x}Ge_x$/Si-Heterojunction Internal-Photoemission Detectors

Cutoff wavelengths can be tailored by choice of Ge content.

NASA's Jet Propulsion Laboratory, Pasadena, California

Infrared detectors based on internal photoemission at $Si_{1-x}Ge_x$/Si heterojunctions have exhibited photoresponses at wavelengths from 2 to 12 μm in initial tests. In principle, the cutoff wavelengths and other aspects of the photoresponses of these detectors can be tailored over the wavelength range from 1 to >20 μm; this enables optimization with respect to performance and required cooling. Because these detectors are compatible with silicon devices in general, it should be possible to integrate them with silicon readout circuitry without the thermal-expansion mismatch that is encountered with present

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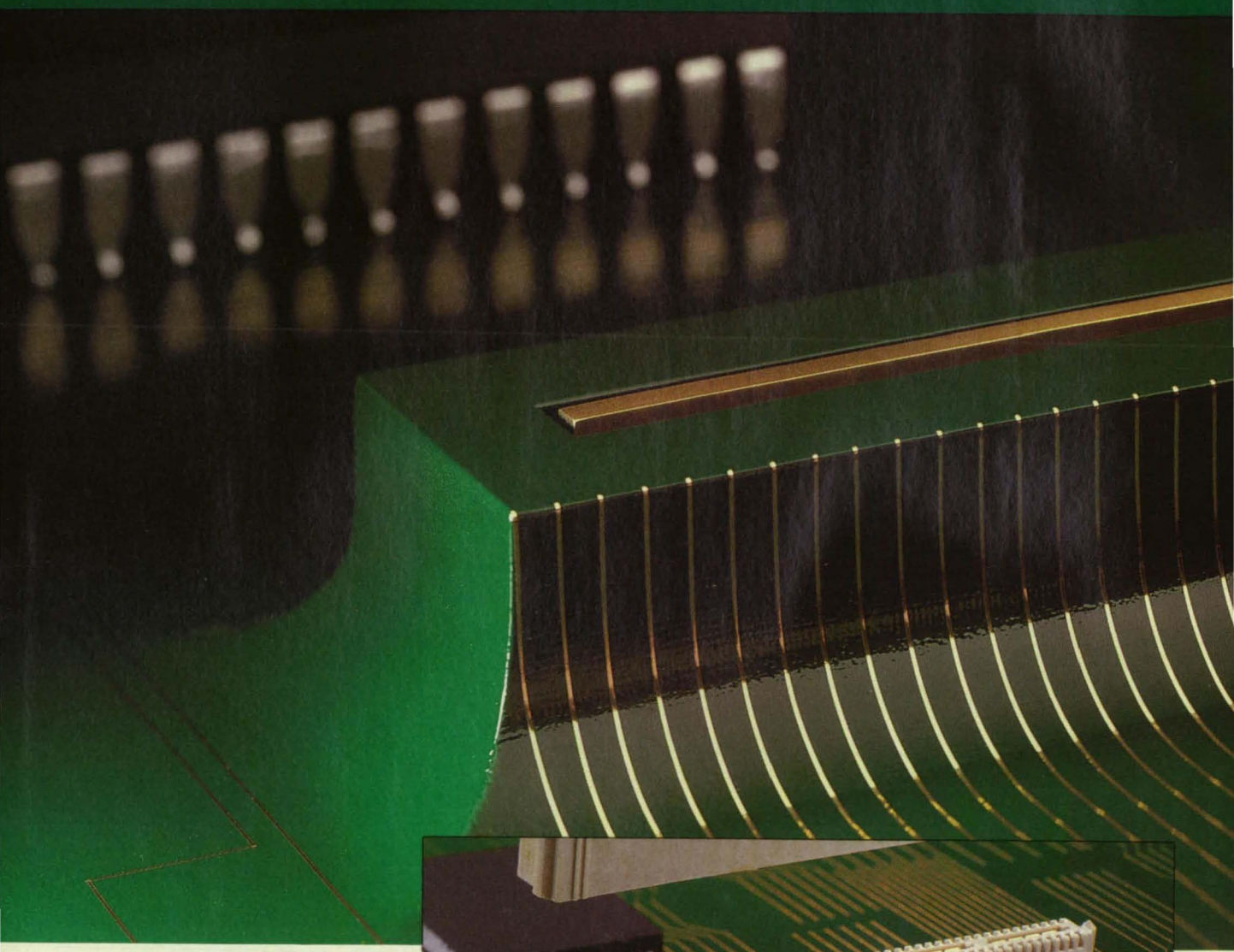

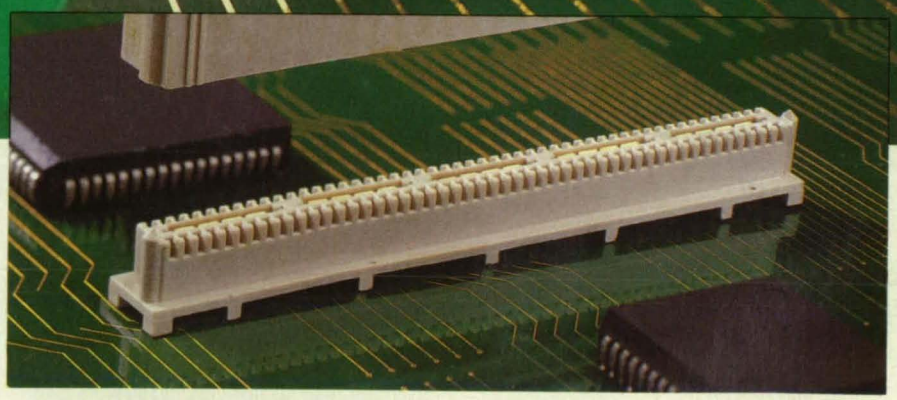

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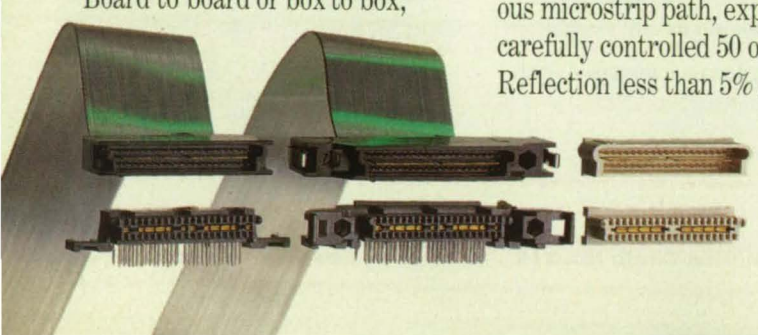

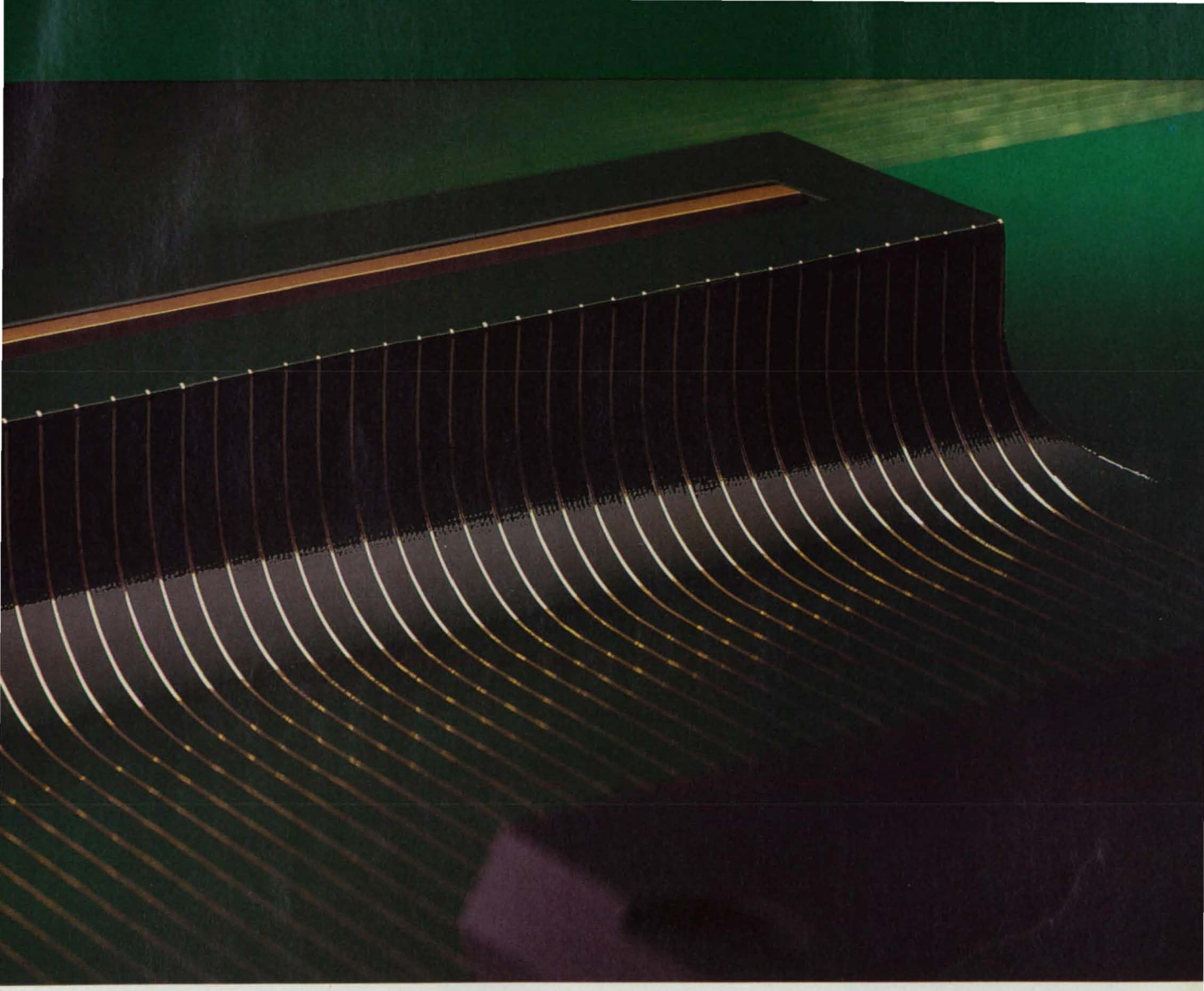

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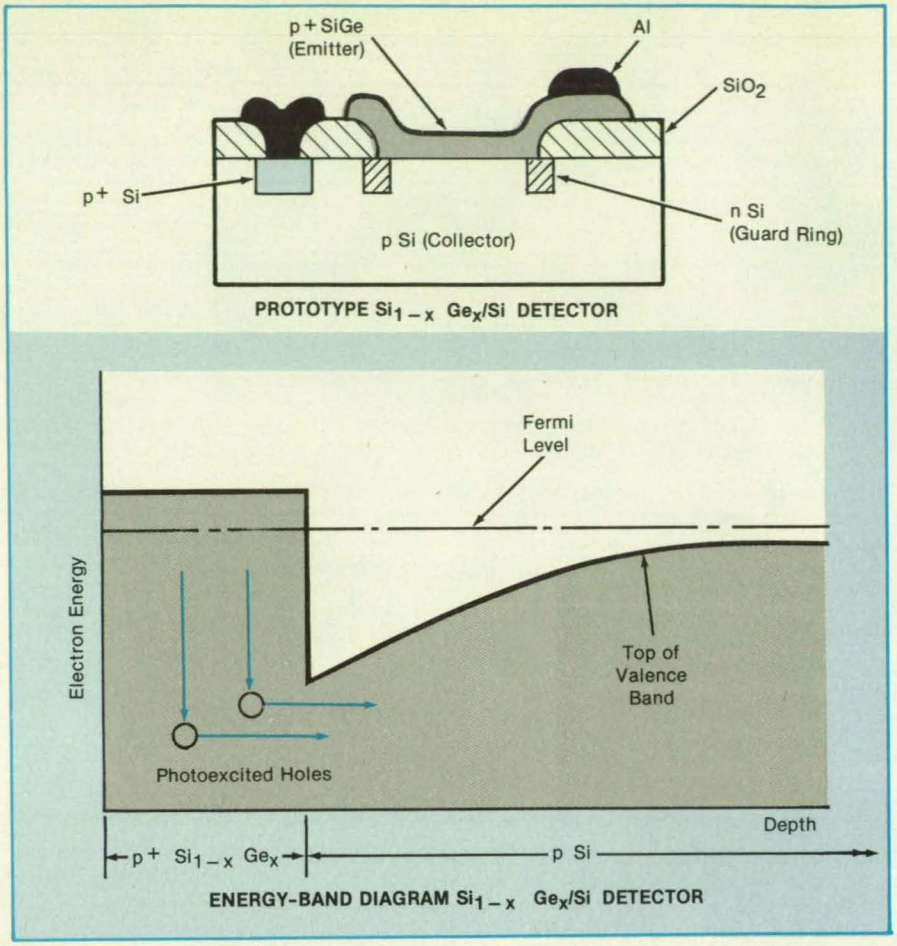

$Si_{1-x}Ge_x$/Si-Heterojunction Internal-Photoemission Detectors can be tailored for use at wavelengths of the order of 10 μm. Future developments are expected to include the integration of such devices with silicon readout circuitry to form infrared-imaging arrays.

HgCdTe infrared detectors. Thus, imaging arrays that operate in the important wavelength range of 8 to 12 μm could be fabricated relatively inexpensively for use in outer-space, military, and industrial applications.

The figure shows a typical detector of this type, which includes a degenerately-p^+-doped $Si_{1-x}Ge_x$ layer (which serves as the photoemitter) on a p-doped Si substrate (which serves as the collector). The mechanism of detection consists of the generation of holes by absorption of photons in the p^+ $Si_{1-x}Ge_x$ photoemitter followed by internal photoemission of the holes over the potential barrier at the $Si_{1-x}Ge_x$/Si heterojunction.

By selecting the Ge content, x, of the photoemitter, one can set the height of the potential barrier and thereby set the cutoff wavelength. One can also tailor other aspects of the photoresponse by the selection of thicknesses of layers, concentrations of the p^+ dopant (boron), the geometry of the device, optical cavities, stacking, and antireflection coats to optimize its performance for a given application.

The $Si_{1-x}Ge_x$/Si detectors are expected to exhibit internal quantum efficiencies (number of photoexcited holes collected ÷ total number of photoexcited holes) much greater than those of silicide Schottky-barrier photodetectors. One reason is that the band of absorbing energy states in the p^+ $Si_{1-x}Ge_x$ layer is narrow in comparison with that in the emitting layer of a silicide detector. This causes a more abrupt turn-on with decreasing wavelength, which in turn results in useful sensitivities closer to the cutoff wavelength. In contrast, in a Schottky detector, photons can excite charge carriers from states far below the Fermi energy; these carriers often do not have enough energy to overcome the barrier. Near threshold, only the small fraction of the photoexcited carriers that originate from states near the Fermi energy can exceed the barrier energy and thus contribute to the signal. Consequently, the quantum efficiency of a Schottky-barrier detector rises only slowly with energy above the potential barrier. Another reason for the increased quantum efficiency is that in a $Si_{1-x}Ge_x$/ Si detector, photoexcited holes traveling over the potential barrier are less likely to be backscattered at the heterojunction because the ratio between effective masses is more favorable.

This work was done by True-Lon Lin and Joseph Maserjian of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 15 on the TSP Request Card.*

NPO-18450

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These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Examples of Synthesis of Dual-Shaped Reflectors

The validity and utility of a method developed previously are demonstrated.

A report presents examples to demonstrate the validity and utility of a method of synthesis of offset dual-shape reflectors. The reflectors are of the general type used in microwave communications, radar, and radio astronomy.

The method of synthesis was described by the authors in a previous journal article. To recapitulate: the principles of geometrical optics and the constraints and requirements of the problem of synthesis of the shapes of single and dual offset reflectors were collected and developed into a set of nonlinear first-order partial differential equations. Methods of solving these equations numerically were described.

The current report reviews the derivation of the partial differential equations and the iterative method of numerical solution. It discusses the significance of the starting point of the numerical integration on each reflector surface; this point could be at the center, on the outer rim, or, most generally, at an interior point.

It emphasizes that one of the notable attributes of the partial differential equations is the speed with which they can be solved — less than 45 seconds on some personal computers and in a fraction of a second on a mainframe supercomputer. It demonstrates the utility of this speed by incorporating the synthesis computer program developed previously into a multiparameter optimization program that performs the synthesis many hundreds or even thousands of times to optimize chosen parameters of the system. Object functions or goals of the optimization procedure can include, for example, mapping equations that yield a low-cross-polarization radiation pattern. Another object function could be a prescribed outer projected perimeter (e.g., circular) of the main reflector when the starting point for the numerical integration on each reflector is the center or an interior point.

Three examples are presented. In the first example, a Gregorian design with a feed hole in the main reflector is synthesized to illustrate the utility of starting the numerical integration at an interior point. In the second example, a dual offset reflector of 120-wavelength diameter is designed via a combination of synthesis and gradient-optimization software to obtain a low-spillover, low-cross-polarization antenna system. This system is then analyzed by various combinations of geometrical and physical optics (diffraction) to illustrate the validity of the synthesis.

In the third example, the synthesis program is integrated into an existing gradient-optimization program to optimize a dual-offset-reflector antenna in such a way that (1) the new main reflector is shaped to a "best fit" with an existing paraboloidal reflector that is to be reconfigured into the new design, and (2) the antenna produces low cross-polarized radiation with low spillover or low noise temperature. The resulting design is subjected to a full diffraction analysis to illustrate its validity.

This work was done by Victor Galindo and William A. Imbriale of Caltech and Raj Mittra of the University of Illinois for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Theory of synthesis of offset dual-shaped reflectors — case examples," Circle 43 on the TSP Request Card.*
NPO-18340

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Integrated-Circuit Pseudorandom-Number Generator

This device produces 8-bit pseudorandom numbers at a rate of 10 MHz.

NASA's Jet Propulsion Laboratory, Pasadena, California

The figure shows essential features of an integrated circuit that produces 8-bit pseudorandom numbers from a specified probability distribution, at a rate of 10 MHz. By use of Boolean logic, the circuit implements a pseudorandom-number-generating algorithm like the one described in "Digital Pseudonoise Generator" (NPO-16627), *NASA Tech Briefs*, Vol. 10, No. 4 (July/August 1986), page 53.

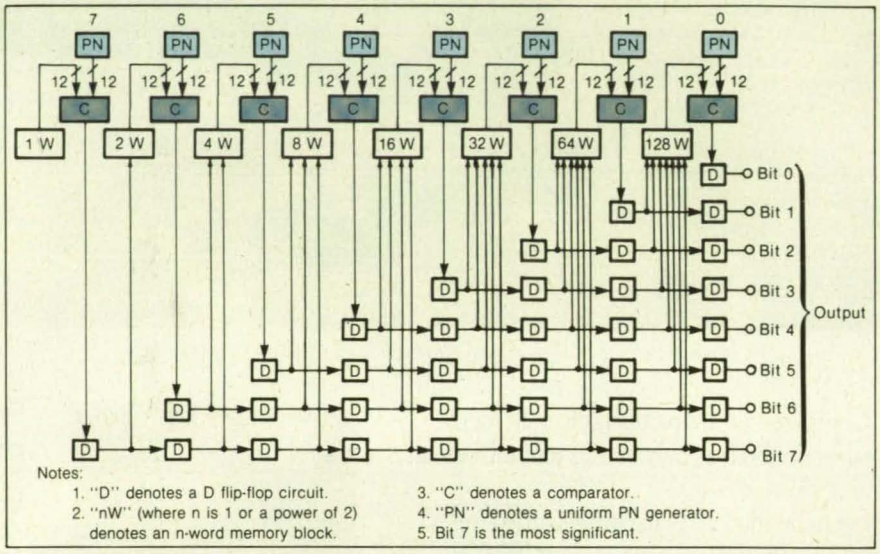
The circuit includes eight 12-bit pseudorandom-number generators, the outputs of which are uniformly distributed. These pseudorandom-number generators are cellular automatons, which are an improvement over the typical linear feedback shift register because the outputs exhibit less correlations. These outputs are processed partly separately and partly together according to the algorithm to yield the final output stream of 8-bit pseudorandom numbers that satisfy the specified probability distribution.

The operation is best explained starting with bit 7: The output of pseudorandom-number generator 7 is compared with the mean of the specified distribution, which has been stored in advance in a one-word (12 bits per word) memory block. The output of comparator 7 is thus a stream of 1-bit pseudorandom numbers, the mean of which equals the mean of the distribution. The output of comparator 7 is fed through a delaying chain of eight D flip-flops to the bit-7 output terminal.

Depending on whether the output of comparator 7 is 0 or 1, the output of pseudorandom-number generator 6 is compared with one or the other of two 12-bit numbers stored in advance in a two-word memory block. These numbers are conditional probabilities for zeros and ones that satisfy the specified probability distribution. Thus, the output of comparator 6 is a 1 or a 0 that depends on bit 7 and the specified distribution. The output of comparator 6 is fed through a delay chain of seven D flip-flops to the bit-6 output terminal.

The fifth bit is generated similarly, except that a four-word memory block is required to store the four conditional probabilities, one of which is selected for comparison according to the combination of the D-flip-flop-delayed outputs of comparators 7 and 6. This process continues through the remaining bits, with doubling of the size of the memory block for the next less-significant bit, and each bit is affected by the previously generated, D-flip-flop-delayed more-significant bits.

Thus, pseudorandom bits are generated on each clock cycle and fed into a "pipelined" system. After an initial delay of eight clock cycles, during which bits propagate through the chains of comparators and D flip-flops, the "pipeline" produces a new 8-bit random number on each clock cycle.



8-Bit Pseudorandom Numbers that satisfy a specified nonuniform probability distribution are generated by processing the uniformly distributed outputs of eight 12-bit pseudorandom-number generators through a "pipeline" of D flip-flops, comparators, and memories that implement conditional probabilities on zeros and ones.

This work was done by James E. Steelman, Jeff Beasley, Michael Aragon, Francisco Ramirez, Kenneth L. Summers, and Arthur Knoebel of Regents of New Mexico State University for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 5 on the TSP Request Card. NPO-18507*

Optical-Input, Optical-Output Morphological Processor

Some of the advantages of optical and electronic processing would be combined.

NASA's Jet Propulsion Laboratory, Pasadena, California

The proposed optical-input/optical-output morphological processor would be an optoelectronic assembly that would perform some binary operations on the picture elements of a binary (black and white) input image, yielding a processed binary output image. The binary operations would occur in a programmable silicon-based very-large-scale integrated (VLSI) logic circuit, which would be sandwiched between the two VLSI optoelectronic input and output image planes (see Figure 1).

A number of such processors could be cascaded to form a more complicated image-processing system. The use of optics as the connection medium would make the rate of processing faster than it is in an all-electronic system designed to perform the same overall processing functions. At the same time, the use of electronics as the processing medium would provide the flexibility of reconfiguration (i.e., programmability) that is not available in an all-optical system. Thus, the processor would combine some of the advantages of both optical and electronic processing.

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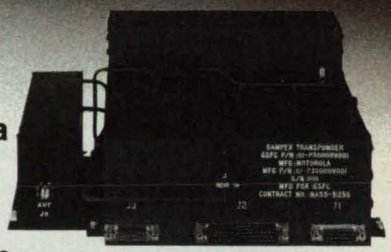

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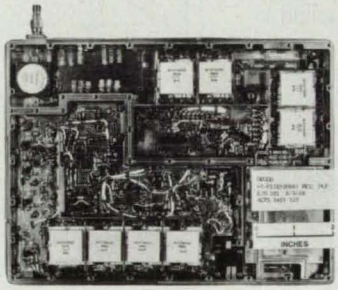

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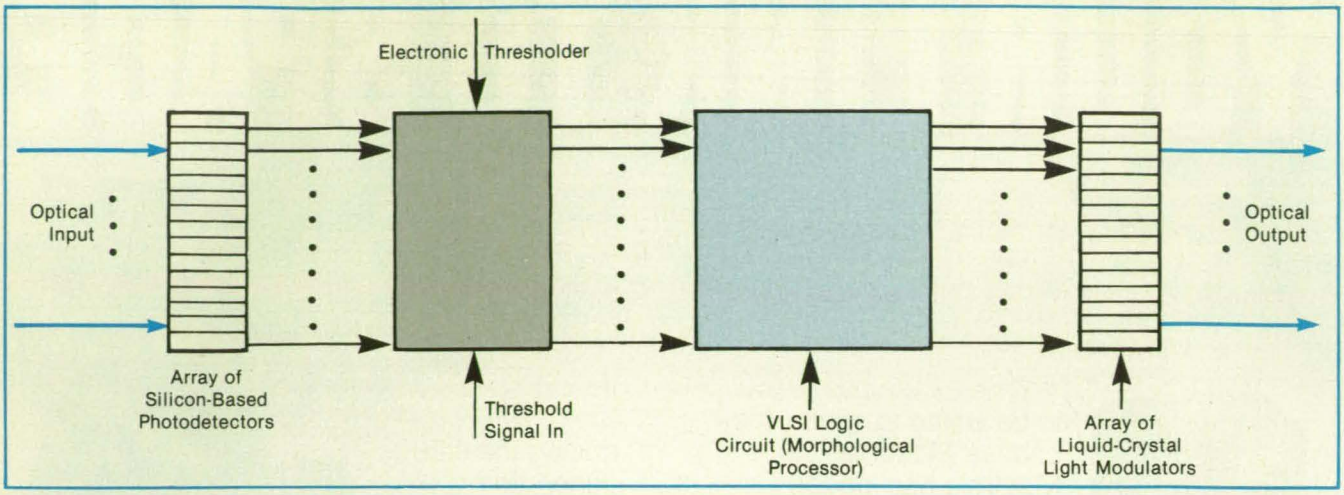

Figure 1. The **Optical-Input, Optical-Output Morphological Processor** would offer the speed of optical connection with other processors and the programmability of electronic internal logic circuitry.

The input image plane would lie on the face of an array of silicon photodetectors that would be part of the VLSI logic circuit; each photodetector would be associated with one of the elements of the logic array and would define one picture element. The output image would be formed on an array of ferroelectric-liquid-crystal light modulators, each of which would define one picture element and would be associated with the corresponding picture element of the VLSI processing circuit and input array. The output voltage of each element of the VLSI logic array would constitute the modulating voltage applied to each optical-output element.

Figure 2 illustrates two logical operations, called "erosion" and "dilation," that the processor might be programmed to perform simultaneously on every picture element and four of its nearest neighbors. Two processors could be cascaded to perform erosion followed by dilation, this sequence of operations being useful in eliminating single isolated white picture elements in otherwise black areas ("salt" noise). Similarly, two processors could be cascaded to perform dilation followed by erosion to eliminate single isolated black picture elements in otherwise white areas ("pepper" noise). One could then also cascade four processors to obtain erosion, dilation, dilation, then erosion to eliminate both salt and pepper noise.

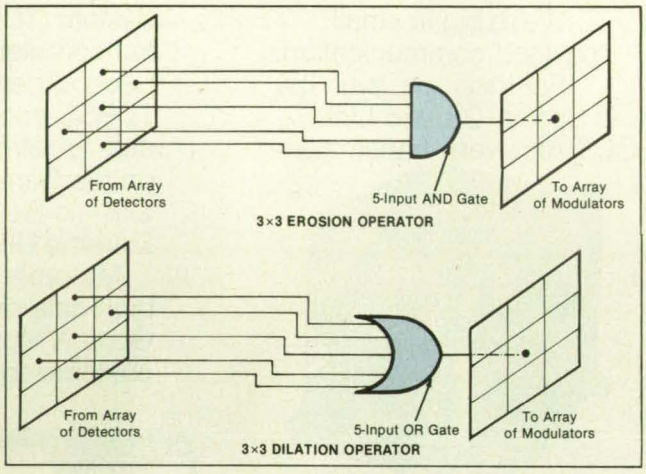

Figure 2. The **Erosion and Dilation Operations** are the logical AND and the logical OR, respectively, of the values (1 for white, 0 for black) represented by the brightnesses of adjacent picture elements.

This work was done by Jeffrey W. Yu, Tien Hsin Chao, Li Jen Cheng, and Demetri Psaltis of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 22 on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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Refer to NPO-18174, volume and number of this NASA Tech Briefs *issue, and the page number.*

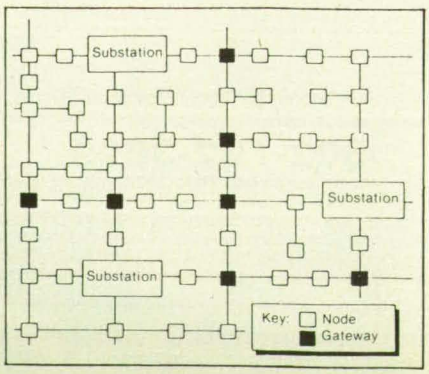
Multiple-Ring Digital Communication Network

An optical-fiber communication system would be overlaid on an electric-power-distribution network.

NASA's Jet Propulsion Laboratory, Pasadena, California

An optical-fiber digital communication network has been proposed to support the data-acquisition and control functions of electric-power-distribution networks. The optical-fiber links of the communication network would follow the power-distribution routes. Since the fiber can cross open power switches, the communication network would include multiple interconnected loops with occasional spurs (see figure). At each intersection a node is needed. The nodes of the communication network would also include power-distribution substations and power-controlling units. In addition to serving data acquisition and control functions, each node would act as a repeater, passing on messages to the next node(s).

Network topology is arbitrary, governed by the power system. The token-ring protocols that are used in single-ring digital-communication networks are not adequate



The **Multiple-Ring Communication Network** would operate on the new AbNET protocol and would feature fiber-optic communication.

for this more complicated network. A new protocol has been developed.

Initially, a message inserted anywhere in the network would pass from node to node throughout the network, eventually reaching all connected nodes. On the first reception of a message, each node would record an identifying number and retransmit the message to the next node(s). On second reception of the same message, each node would recognize the identifying number and refrain from retransmitting the message. This would prevent the endless repetition and recirculation of messages. This aspect of the protocol resembles the behavior of T-cells in the immune system, which learn to recognize invading organisms on first exposure and kill the invading organisms with antibodies when they encounter the organisms again. For this reason, the protocol is called "AbNET" after the microbiologists' abbreviation "Ab" for "antibody." The AbNET protocols include features designed to maximize the efficiency and fault-tolerant nature of the approach. Multiple service territories can be accommodated, interconnected by "gateway" nodes (see figure).

The AbNET protocol is expected to enable the network to operate as economically as does a single ring that includes an "active monitor" node to prevent the recirculation of messages. With AbNET the performance of the proposed network would probably exceed that of a network that relies on a central unit to govern the routes of messages. Communications would automatically be maintained in the remaining intact parts of the network even if fibers were broken.

For the power-system application, the advantages of optical-fiber communication include electrical isolation and immunity to electrical noise. The AbNET protocols augment these advantages by allowing an economical system to be built with topology-independent and fault-tolerant features.

This work was done by Harold Kirkham of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 28 on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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Refer to NPO-18133, volume and number of this NASA Tech Briefs *issue, and the page number.*

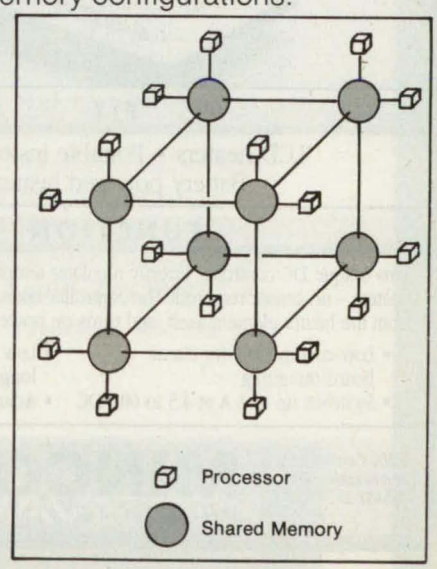
Hypercluster Parallel Processor

The same equipment can be connected in shared- or distributed-memory configurations.

Lewis Research Center, Cleveland, Ohio

The hypercluster is a computer system that includes multiple digital processors, the operation of which is coordinated through specialized software. It is configurable according to various parallel-computing architectures of the shared-memory or distributed-memory class (see figure), including scalar computer, vector computer, reduced-instruction-set computer (RISC), and complex-instruction-set computer (CISC). Any or all of these computing architectures of either class or both classes can coexist within the hypercluster.

The hypercluster is not meant so much to provide a significant improvement over present supercomputers of fixed, specialized architecture. Rather, it is designed as a flexible, relatively inexpensive system that provides a single programming and operating environment within which one can investigate the effects of the various parallel-computing architectures and combinations thereof on performance in the solution of complicated problems like those of three-dimensional flows in turbomachines. The more-expensive alternative to the development of the hypercluster would have been the purchase of two or more



This **Configuration of Processors and Memories** is one of many multilevel shared-memory/distributed-memory/distributed-processor configurations encompassed by the hypercluster concept.

commercial parallel computers representative of each architectural class. The hypercluster enables the concurrent application of a variety of computing architectures to the problem under study and provides a unique, multilevel computing architecture that does not exist in any commercial parallel computer.

The hypercluster equipment is based on the relatively inexpensive, standard VME bus microcomputer circuit boards. Consequently, the processing elements can be reconfigured and upgraded easily as microprocessor technology evolves. The processing elements need not be homogeneous: different processors, each performing the types of operations for which it is best suited, can be incorporated into the hypercluster system. Because the hypercluster software and architectural concepts are in the public domain, anyone may implement the relatively inexpensive hypercluster approach in research on parallel computing.

This work was done by Richard A. Blech, Gary L. Cole, and Edward J. Milner of **Lewis Research Center** *and Angela Quealy of Sverdrup Technology Inc. For further information, Circle 42 on the TSP Request Card.*

LEW-15283

Compensating for GPS Ephemeris Error

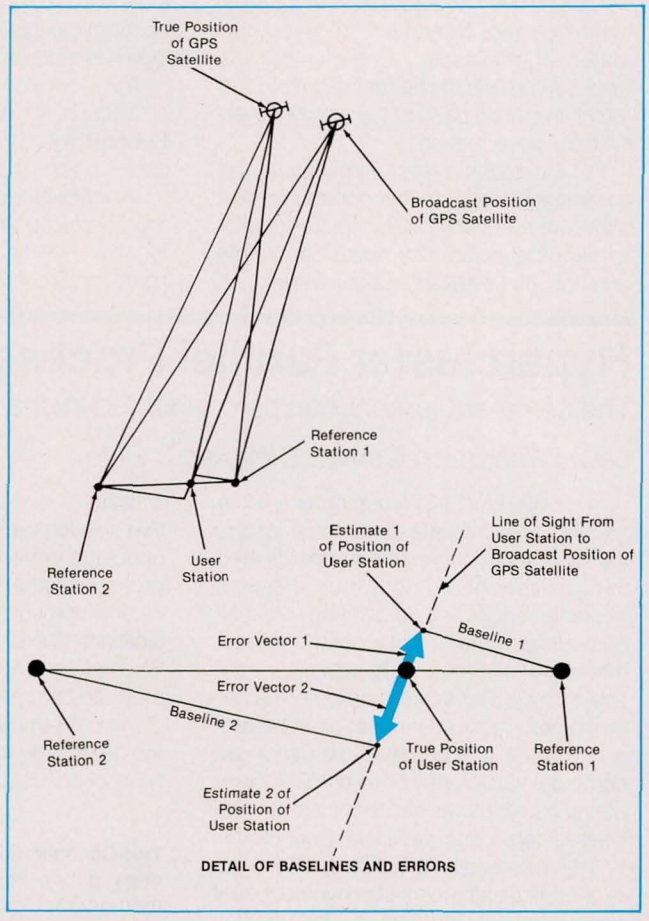
Most of the error in the position of a user station can be eliminated.

NASA's Jet Propulsion Laboratory, Pasadena, California

A method of computing the position of a user station that receives signals from the Global Positioning System (GPS) of navigational satellites compensates for most of the GPS ephemeris error. The GPS is primarily a military system, and the broadcast GPS ephemeris data include errors that are introduced deliberately to degrade the accuracies available to users who lack access to the applicable error-correcting codes. A receiving station that is thus nonprivileged and uses the GPS in the simplest conventional method (processing signals received simultaneously from four or more GPS satellites) can compute its position to within about 100 m. The present method enables the user station to reduce the error in its computed position substantially.

Of course, the method involves a "catch": the user station must have access to two or more reference stations at precisely known positions several hundred kilometers apart and must be in the neighborhood of the reference stations. The method is based on the fact that when GPS data are used to compute the baseline between a reference station and the user station, the vector error in the computed baseline is proportional (to a first approximation) to the ephemeris error and to the length of the baseline.

First, the baseline vectors from the reference stations to the user station are estimated from the GPS measurements, using the somewhat erroneous broadcast GPS ephemeris data. This results in slightly different user positions — one for each reference station. The final estimate of the position of the user station is then computed as a weighted average, in which the weight of each vector is chosen to be inversely



The User Station makes two slightly erroneous initial estimates of its position by computing baselines from two or more reference stations from broadcast, slightly erroneous GPS ephemeris data. The estimates can be combined in a way that reduces or eliminates the error. This is a simplified view: the user station need not be located on a line between reference stations.

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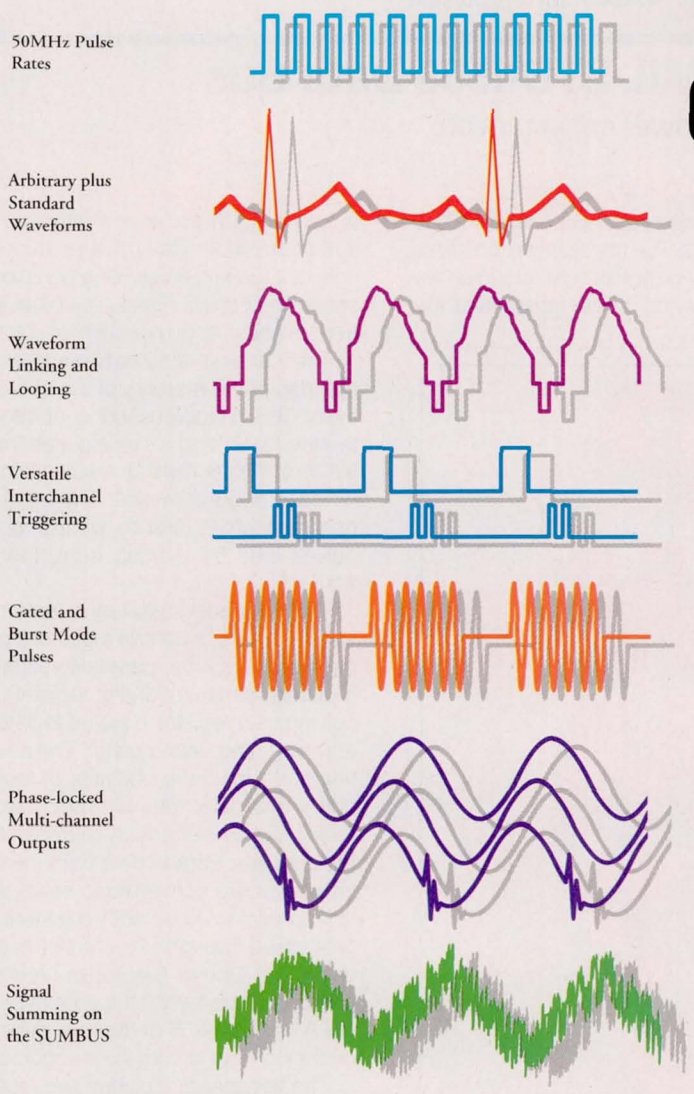

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The new 1395 arb is so versatile that most complex waves can be produced by a single unit. With up to 128K points and ten built-in functions, plus linking and looping, there's no more powerful arb on the VXIbus. The 1391 Pulse Generator, too, has a wide selection of outputs with exceptional waveform quality, variable transition times, gated and burst modes, and square waves to 100 MHz.

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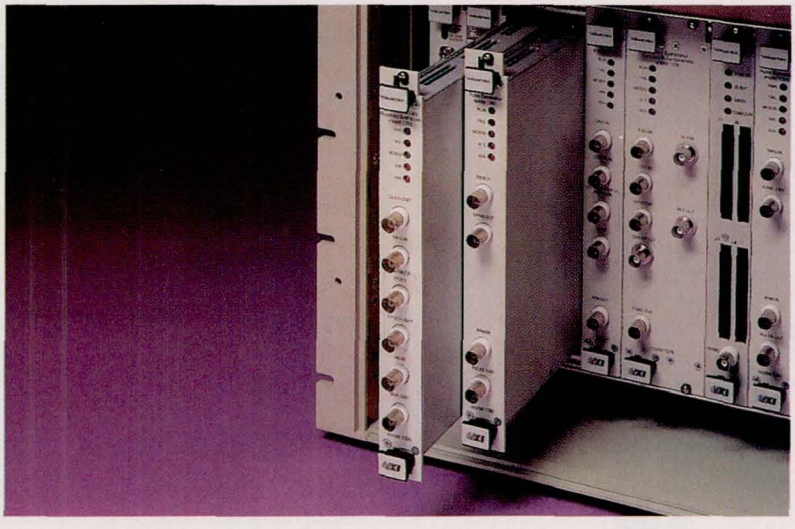

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For Literature Circle No. 395
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proportional to the length of its baseline. This weighting equalizes the magnitudes of the ephemeris-error contributions of the position vectors, thereby providing for vector-sum cancellation of equally large (but oppositely directed) components of ephemeris error in the position of the user station.

This work was done by Jiun-tsong Wu of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 16 on the TSP Request Card.*
NPO-18416

Interface for Dual-Channel MIL-STD-1553 Data Bus

Principal advantages are flexibility and low power consumption.

Lewis Research Center, Cleveland, Ohio

A digital electronic subsystem made of commercially available programmable logic arrays and discrete logic devices serves as an interface between a microprocessor and a dual-channel MIL-STD-1553 data bus. The subsystem consumes only 800 mW of power (not including the power consumed by the transceiver that is part of it). It provides flexibility in that it is controllable via firmware. It includes only two reading-and-writing ports: one for status and control signals, the other for the transmission and reception of data.

The interface requires two addresses in the map of the memory of the microprocessor. The microprocessor controls the interface by writing to, or inquires into the status of the interface by reading from, one of these two addresses. The microprocessor transmits data by writing to, or receives data by reading from, the other address.

The interface includes a transmitting state machine, a control register, a receiving state machine, parallel-to-serial shift registers, serial-to-parallel registers, a receiving data register, a status register, and a transmitting data register. The transmitting state machine consists of logic circuitry that generates all the control and timing signals necessary to transmit over the data bus. Parallel data from the microprocessor are converted to serial data in the parallel-to-serial shift registers, then processed through Manchester encoder/decoders. One of the transmitters in the transceiver transmits the data over channel A or channel B of the bus, depending on the command from the microprocessor.

The transceiver includes two receivers: one for channel A and one for channel B. Incoming data are Manchester-decoded and converted from serial to parallel. If the incoming message is a command, the beginning of which bears the correct remote-terminal address, the receiving state machine generates a signal that interrupts the microprocessor and informs it that a command is being received. In effect, the microprocessor receives an early warning that the rest of the message is about to follow. The status register contains the remote-terminal address and signals from both Manchester encoder/decoders to inform the processor of the status(es) of message(s), and of the channel(s) on which a message or messages is or are coming in on the bus.

This work was done by Bryan L. Davies and Timothy L. Heaps of Rockwell International Corp. for **Lewis Research Center**. *For further information, Circle 7 on the TSP Request Card.*
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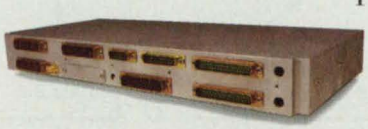

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Memory Network for Distributed Data Processors

Dissimilar computers share data at memory-bus speeds.

Ames Research Center, Moffett Field, California

The Universal Memory Network (UMN) is a modular, digital data-communication system that enables computers with differing bus architectures to share 32-bit-wide data between locations up to 3 km apart with less than one millisecond of latency. This network makes it possible to design sophisticated real-time and near-real-time data-processing systems without the data-transfer "bottlenecks" that now exist between computers using the typical communications protocols. This enterprise network permits the transmission of a volume of data equivalent to an average encyclopedia each second (40 MB/s). Examples of facilities that can benefit from the Universal Memory Network include telemetry stations, simulation facilities, powerplants, and large laboratories (e.g., particle accelerators), or any facility that shares very large volumes of data.

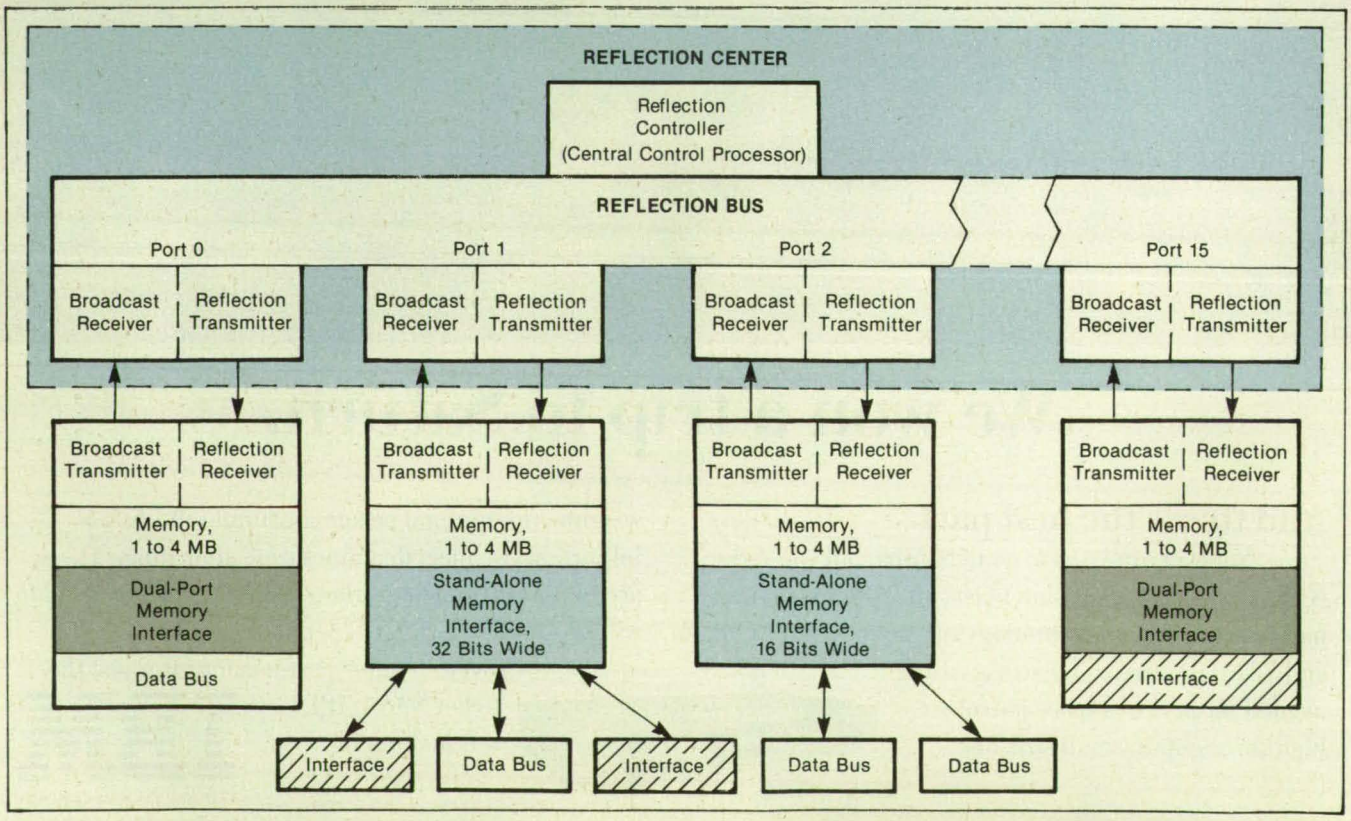
The main hub of the UMN is the reflection center — a subsystem containing a central control processor (the reflection controller) and a data bus (the reflection bus) equipped with 16 dual memory ports. Various configurations of host computers, workstations, fileservers, smaller networks on subnetworks of computers (see figure) can be interconnected, providing memory speed bandwidth connectivity. The reflection center provides full duplex communications between the ports, thereby effectively combining all the memories in the network into a dual-ported, random-access memory. This dual-port characteristic eliminates the CPU overhead on each computer, which is required with typical EtherNet or FDDI networks.

The reflection bus carries write transfers only and operates at a sustained data rate of 40 MB/s (this does not include address, error correction, and coordination information, which makes actual UMN bus traffic approach 100 MB/s). The UMN can be implemented in copper cables for distances up to 50 ft (15 m) and/or in fiber optics for distances up to 3 km. Combinations of both media can be used in the same network. Multiple reflection centers can be interconnected to obtain configurations requiring more ports.

In addition to the reflection center of main hub, the UMN includes smaller hubs called Shared Memory Interfaces (SMI), which make it possible for computers based on different bus architectures (e.g., SELBus, DEC BI, MultiBus, and VME or other selected buses) to communicate via the reflection bus. Each host computer is attached to the reflection center by a bus-interface-circuit card, which translates the read and write transfers of the host computer to and from the reflection-bus standard. This translation centers around the ordering of bytes and conversions used by various vendor architectures to a common strategy required by the 100-nanosecond-cycle time of the reflection bus.

The Shared Memory Interface enhances the modular nature of the network. It provides computer memory access to processors of lower cost and enables a large number of workstations to be supported from one reflection center. For example, one reflection center can support up to 12 SMI memory interfaces, each with capacity to support between 8 and 16 workstations, depending on local hardware configurations. Multiple reflection centers can be interconnected to support even more workstations.

This work was done by David Bolen, Dean Jensen, Ed Millard, Dave Robinson, and George Scanlon of Computer Sciences Corp. for **Dryden Flight Research Facility**. *For further information, Circle 40 on the TSP Request Card.*
ARC-13095



The **Universal Memory Network** is modular and flexible. It provides memory-speed data communications among computers at NASA's new Integrated Test Facility (ITF).

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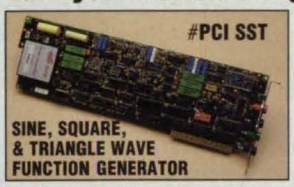

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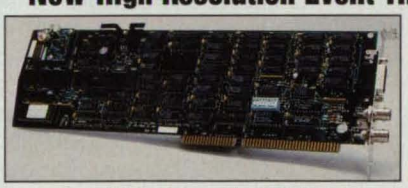
New High-Resolution Event Timing Controller



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Redlake's **TapeCaster** converts VGA screen output to video for applications such as recording animation and creating training tapes. The TapeCaster is extremely easy to use: no base addresses, no interrupts, no software required — just plug and play.

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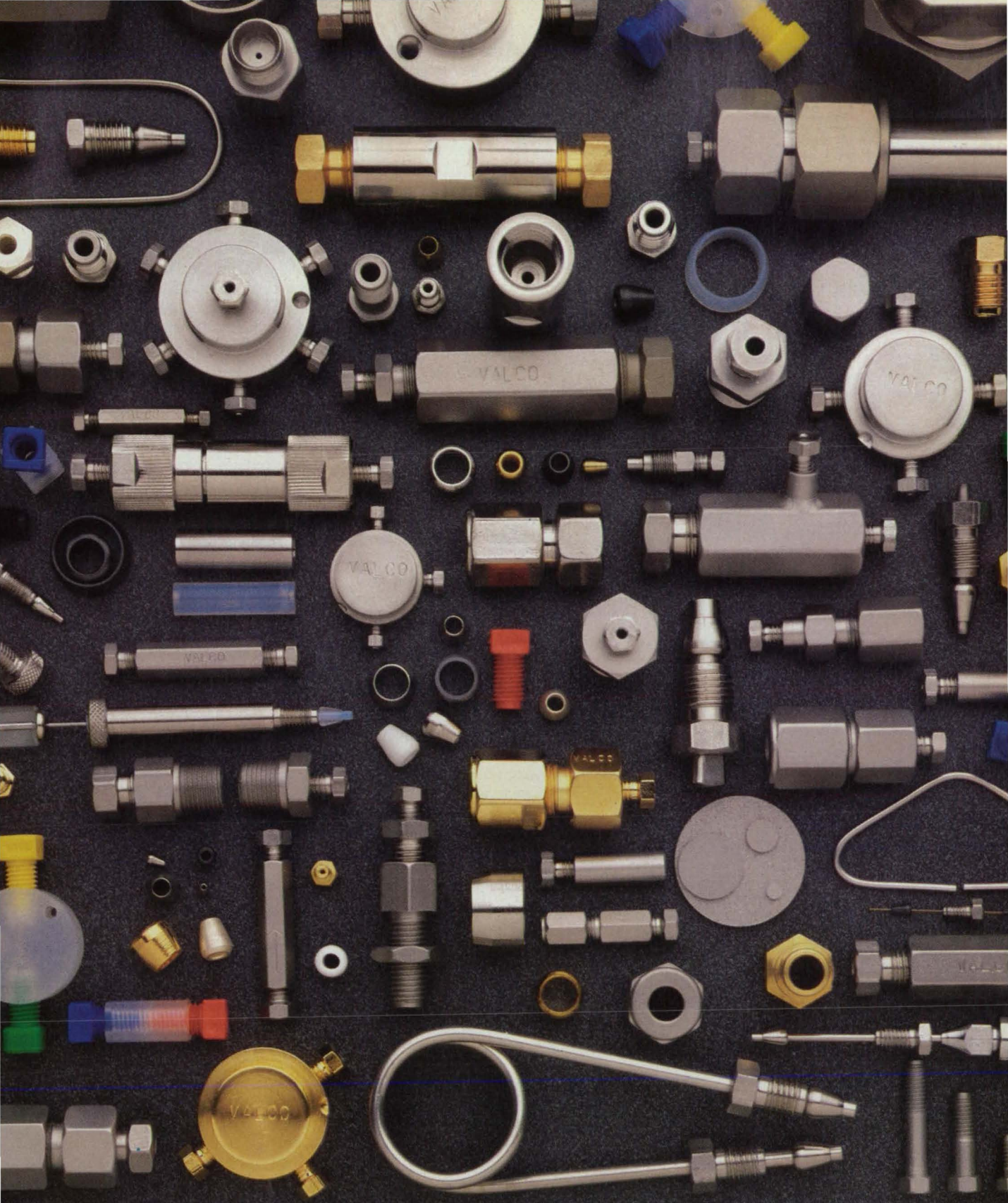
Accuracies of Optical Processors for Adaptive Optics

In comparison with digital electronic processing, optical processing offers greater speed but less accuracy.

A paper presents a theoretical analysis of the accuracies and requirements concerning the accuracies of optical linear-algebra processors (OLAP's) in adaptive-optics imaging systems. An example of an adaptive-optics imaging system is an astronomical telescope in which the primary mirror is divided into segments that are repeatedly adjusted under computer control to correct for atmospheric distortions of the incoming wave fronts. In such a system, the continuing evolution of the atmospheric distortion during the computational delay gives rise to an additional residual component of uncorrected distortion. In principle, an OLAP would be much faster than a digital electronic processor is and could, therefore, eliminate some of the residual distortion. The question is whether the errors introduced by the analog processing of an OLAP would overcome the advantage of greater speed.

This paper addresses the issue by presenting an estimate of the accuracy required in a general OLAP that yields a smaller average residual aberration of the wave front than does a digital electronic processor that computes at a given speed. First,the errors that arise in an OLAP at the input-vector (light-source), matrix (spatial-light-modulator), and output-vector (photodetector) planes are discussed. These errors are represented by two independent mathematical models: one for multiplicative and one for additive encoding errors. These models take account of the mean-square wave-front error caused by the atmosphere, wave-front-measurement noise, the shape of the mirror, and the values of the elements of the feedback matrix used to adjust the segments of the mirror. Next, a mathematical model for the residual mean-square wave-front error caused by the computational delay in a digital processor is presented. This model includes terms that represent atmospheric turbulence, the number of segments, the zenith angle of the reference star, and the computational speed, among other things.

The foregoing models are applied in a computer simulation based on a mirror of seven regular hexagonal segments, and the numerical results are presented in



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graphs. The relative merits of an OLAP and a digital processor are evaluated by comparing the wave-front errors introduced by the finite computational speed of the digital processor with the wave-front errors introduced by the inaccuracies in the OLAP. The numerical results could be used as guidelines when deciding whether to use an optical or a digital processor with a mirror of a given size.

This work was done by John D. Downie of **Ames Research Center** *and Joseph W. Goodman of Stanford University. To obtain a copy of the report, "Accuracy Requirements of Optical Linear Algebra Processors in Adaptive Optics Imaging Systems," Circle 2 on the TSP Request Card. ARC-12840*

Development of Maneuvering Autopilot for Flight Tests

Minimum-error-excitation output-feedback design worked well.

A report describes recent efforts to develop an automatic control system that would operate under the supervision of a pilot and make an airplane follow prescribed trajectories during flight tests. This report represents additional progress on this project, parts of which have been described in previous documents. Here, the emphasis is on the acquisition of four types of expertise: (1) the mathematical modeling of maneuvers; (2) the application of modern linear, multivariable synthesis of mathematical models of control systems; (3) techniques for the development of reference-command and gain-scheduled perturbation controllers; and (4) investigation of the emerging use of prelinearizing transforms in the design of nonlinear systems.

The main text of the report is presented in nine sections. Section 1 gives background information on the technology of the control of test-flight trajectories, a summary of previous developments, and a brief description of the subject matter of the report. Section 2 presents mathematical models of the airframe, engine, and command-augmentation system (a subsystem that includes some of the aerodynamic control surfaces). The integration of these models into the overall linear model for the design and evaluation of the control system is discussed.

Section 3 focuses on the mathematical modeling of maneuvers. It describes flight-test trajectories characterized by constraints on components of position, constraints on components of velocity and altitude, or constraints on combinations of load, speed, and altitude. Mathematical models of eight general types of trajectory are presented.

Section 4 addresses the design of autopilots for maneuvers. A first subsection shows how a table of trim values can be used to develop what amounts, in effect, to a piecewise-linear model of the entire flight-test system of the F-15 airplane for the design and evaluation of the dynamic response of the airplane in specified nonlinear maneuvers. A second subsection describes two different linear techniques for the design of control systems: eigenstructure-assignment design and minimum-error-excitation output-feedback design. A third subsection contains a brief discussion of nonlinear controllers.

Section 5 discusses the numerical simulation and evaluation of the results of the simulation of eight maneuvers under the control of a simulated autopilot. Section 6 presents a summary and a discussion of future work. Among the conclusions stated in this section are the following:

- The use of a guaranteed stability margin is a powerful technique in the design of control systems represented by high-order augmented and coupled mathematical models.
- The eigenstructure-assignment method was abandoned because there appears to be no direct way to use it in a converging-iterative-design approach.
- The minimum-error-excitation output-feedback method with a guaranteed-stability-margin, full-state design worked well under all simulated flight conditions.

This work was done by P. K. A. Menon and R. A. Walker of Integrated Systems, Inc., for **Ames Research Center**. *Further information may be found in NASA CR-179428 [N88-16707], "Aircraft Flight Test Trajectory Control."*

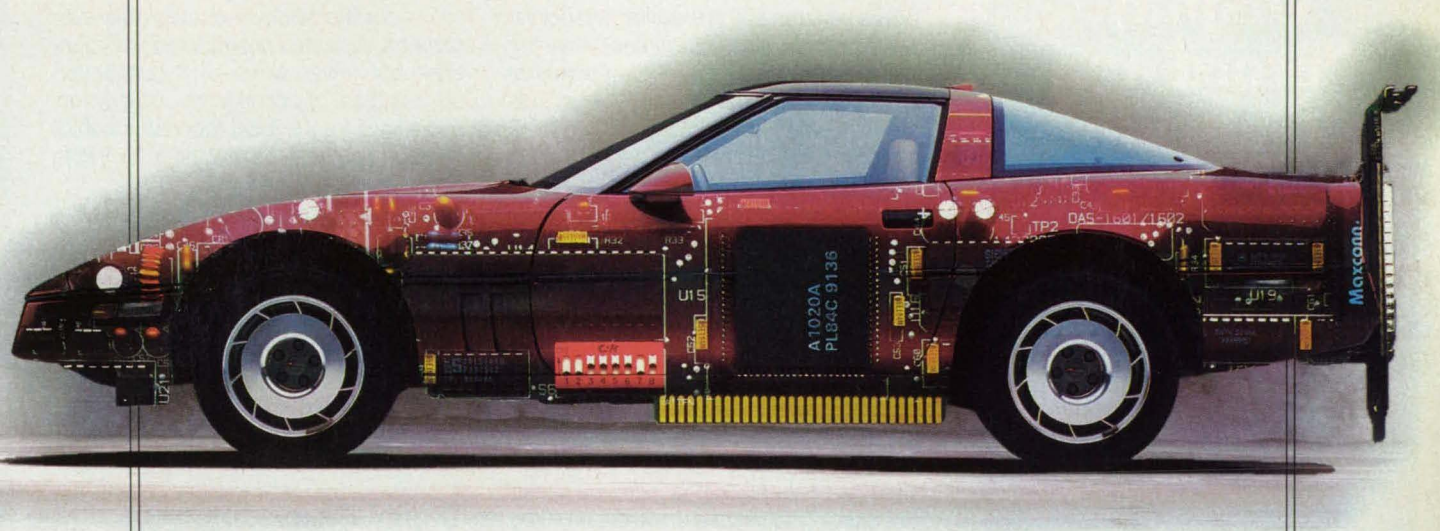
Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
ARC-12166

Nested Neural Networks

Many patterns of different sizes can be stored and retrieved.

A report presents a theoretical analysis of nested neural networks, which consist of interconnected subnetworks (and each subnetwork may be subdivided into smaller interconnected subnetworks). Although the analysis is based on simplified mathematical models that are more appropriate for artificial electronic neural networks, it may be partly applicable to biological neural networks, which have been found to exhibit some of the characteristics of nesting.

Neural information is considered to be stored in the synaptic connections and conveyed by patterns of neural states. A neural network is considered to be globally stable if, when probed by any pattern, it converges to a final state that is an equi-



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For More Information Circle No. 619

librium point of the network in the sense that it minimizes an energylike function of the state. The storage capacity of the network has been defined as the number of stored patterns that are equilibrium points. A storage rule that guarantees that the stored patterns are equilibrium points of the network is called a "safe storage" rule for the purpose of this study.

The network structures considered in this study were largely motivated by the observation that while the safe storage of network-size patterns in a large, fully-connected neural network is either unresolvable (if only orthogonal patterns are to be stored) or of little practical use (if only two patterns are to be stored), the subpatterns can be stored safely in relatively small subnetworks, with resultant vast storage capacity of the entire network. In the case of visual patterns, the sizes of the subpatterns are naturally categorized by spatial periods or frequencies in the pattern field. The corresponding subnetworks are subsequently categorized by layers, each corresponding to a spatial frequency. Interlayer connections are suggested by the fact that points in the pattern field may be shared by subpatterns of different sizes. Connecting each neuron at a given layer to its nearest neighbors in lower layers results in the nesting of subnetworks that correspond to neighboring layers and that share a common neuron. The number of consecutive layers connected in this fashion defines the "nesting degree" of the network.

Thus, a nested neural network lends itself readily to the storage and retrieval of information in the form of subpatterns. The storage capacity and the error-correction capability of the subnetworks in a nested network are shown in this study to increase in general with the nesting degree. Storage of only few patterns in each subnetwork is suggested by both physical and information-retrieval considerations. The worst-case storage capacity of nested subnetworks is the same as that of externally disconnected networks of the same size, and their error-correction capability is generally higher. The probability of orthogonality between random patterns is shown to be approximately inversely proportional to the square root of the size of the patterns. It follows that the orthogonality condition can be met sensibly in the storage of subpatterns in a nested network, by use of a simple threshold function.

For random subpatterns stored in relatively large subnetworks, the probabilities of local stability and error correction are shown to increase with the nesting degree. The fact that large patterns often share some or many of their subpatterns implies that the number of different network-size patterns that can be stored and retrieved in the nested network is exponential in the number of the subnetworks. Storage of relatively few subpatterns in each subnetworks results in a vast storage capacity of the entire network, maintaining the stability and error-correction capability of the subnetworks. The nested structure also allows for the retrieval of individual subpatterns. A nested network requires considerably fewer wires and connection devices than fully connected networks do, and allows for the local reconstruction of damaged subnetworks without having to rewire the entire network.

This work was done by Yoram Baram of **Ames Research Center**. *Further information may be found in NASA TM-101032 [N88-30373], "Nested Neural Networks."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. ARC-12274

Digital Frequency Synthesizer for Radar Astronomy

Spectral purity of the output has been analyzed.

A report discusses a conceptual digital frequency synthesizer that would be part of a programmable local oscillator in a radar-astronomy system. From a 100-MHz reference clock signal, the synthesizer is required to produce a nearly sinusoidal output signal, the frequency of which must be adjustable from 0 to 50 MHz in increments of $2^{-48} \times$ the clock frequency (0.36 μHz). The phase must remain continuous during adjustments of frequency, phase noise must be low, and spectral purity must be high.

Although the synthesizer is based on a design concept published in 1971, the report is nevertheless valuable because it discusses the theory of operation in some mathematical detail and presents a new analysis of the spectral purity of the output. The basic principle of operation can be summarized as follows: A binary accumulator synchronized with the clock signal is used as the phase generator, while a read-only-memory lookup table is used to generate the sinusoid at each increment of phase. Because the number of bits that must be used in the accumulator (in this case, 48) to obtain adequate resolution is greater than the number of address bits that can be accommodated in a practical read-only-memory sine generator, the output of the accumulator must be truncated to a smaller number of bits (in this case, 16, corresponding to a phase resolution of about 0.0055°). The output frequency, as a fraction of the clock frequency, F_c, is controlled by an external computer, which supplies a frequency-control word (actually, an integer number, F_f) to the phase generator.

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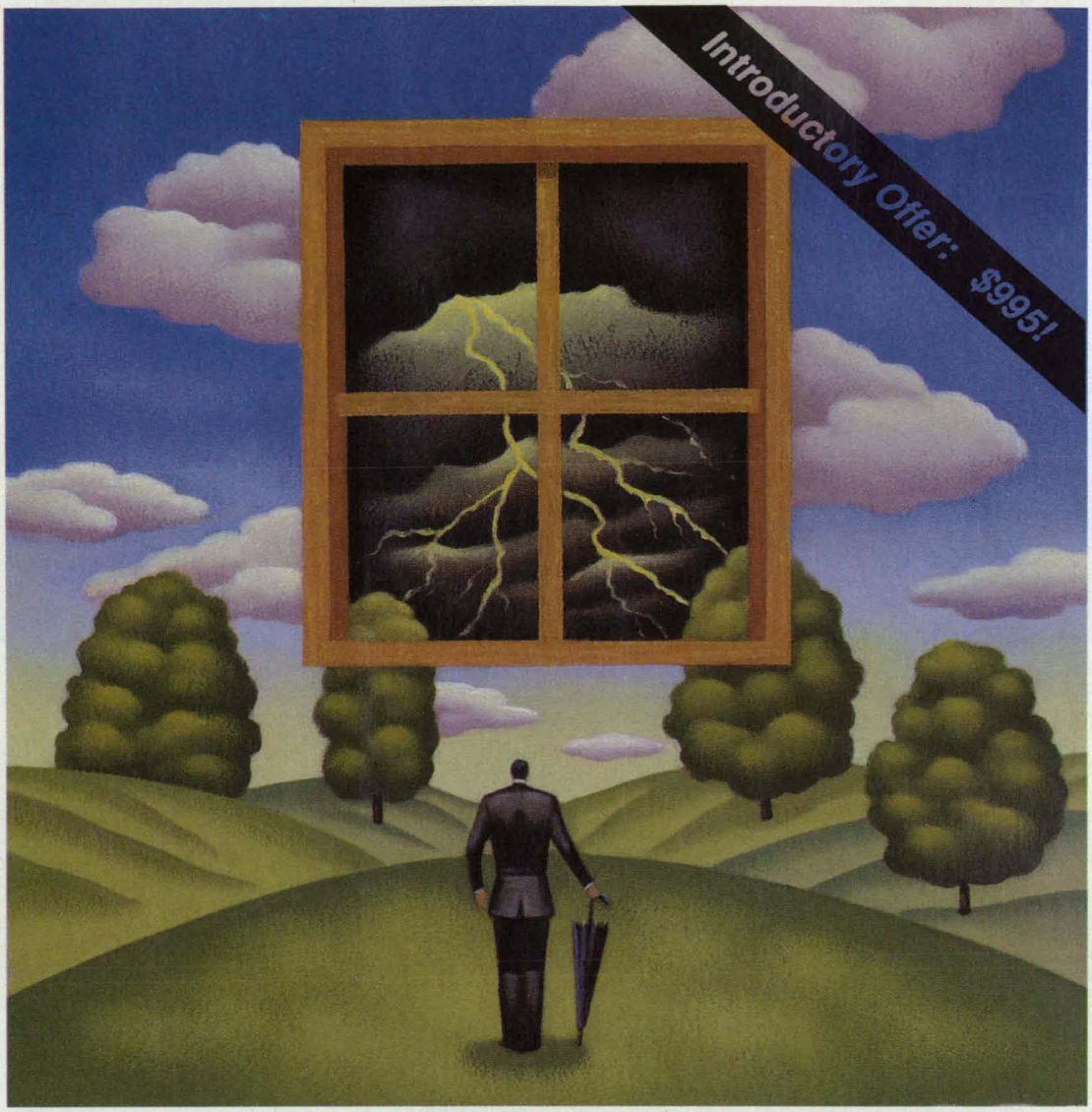

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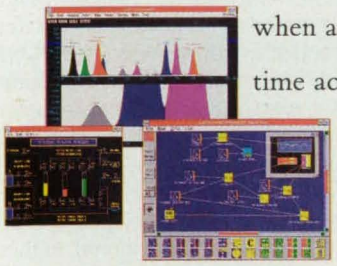

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For More Information Circle No. 423

The analysis of the output spectrum takes account of the relationships among the clock frequency, the number of bits in the accumulator, the frequency control, and the truncation in the output of the accumulator. The spectrum is shown to include "frequency spurs," which are the first N harmonics of a fundamental frequency $F_c F_f / 2^L$, where L is the number of bits in the accumulator (in this case, 48) and $N = 2^L \times$ the greatest common divisor of F_f and 2^L. Equations for the powers in the spurs are derived. The equations are applied to the specific design, and it is shown that the largest spur is about 96 dB below the desired output sinusoid.

This work was done by Ramin Sadr, Edgar Satorius, J. Loris Robinett, Jr., and Erlend Olson of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Digital Frequency Synthesizer for Radar Astronomy," Circle 49 on the TSP Request Card. NPO-18421*

More About Vector Adaptive/Predictive Coding of Speech

Details of design and results of tests are presented.

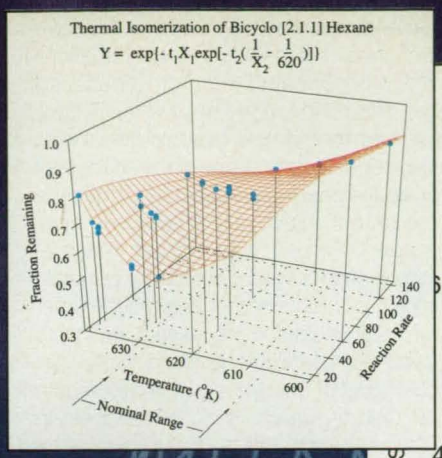
A report presents additional information about the digital speech-encoding and -decoding system described in "Vector Adaptive/Predictive Encoding of Speech" (NPO-17230), *NASA Tech Briefs*, Vol. 13, No. 9 (September 1989), page 40. The basic purpose of this system is to compress a digitized speech signal for transmission at a rate of 4.8 kb/s, then reconstruct a perceptually satisfactory approximation of the original speech signal at the receiver. Toward this end, the raw digitized speech signal (sampled at 8 kHz with a cumulative data rate of 64 kHz) is analyzed in nonoverlapping frame intervals of 22.5 ms, and the data in each frame interval are processed into code vectors according to the adaptive/predictive algorithm, which reduces the data rate by removing much of the redundant content of the data.

The report summarizes the development of the vector adaptive/predictive coding (VAPC) system and describes the basic functions of the VAPC algorithm. It describes refinements that were introduced to enable the receiver to cope with errors; in particular, isolated errors and burst errors in the transmission channel at an average bit-error rate of about 10^{-3}. These refinements include the use of 1 of the 108 bits in each frame to synchronize the frame and the use of 3 of these bits to detect errors.

The frame-synchronization scheme provides, among other things, for resynchronization in the receiver within a short time (<1 s) when synchronization is lost, and for silent output pending recovery of synchronization. The error-detection scheme provides for repetition of the previous frame (up to a maximum of two repetitions), or for silent output until a burst of errors ends; this reduces the perceptual effect of bursts of two frames or shorter. To reduce the perceptual effect of isolated errors, the code vectors and the binary indices thereof are constructed according to a pseudo-Gray-coding scheme.

The VAPC algorithm requires about 4×10^6 multiplications and additions per second; about 8K words of random-access memory are needed for storage of the algorithm and of data. The VAPC algorithm has been implemented in integrated-circuit coding/decoding processors (codecs). VAPC and other codecs were tested under a variety of operating conditions, including between fixed stations and mobile stations aboard land vehicles and aircraft. Tests were also designed to reveal the effects of various background quiet and noisy environments and of poor telephone equipment (e.g., carbon microphone). In these tests, the VAPC was found to be competitive with and, in some respects, superior to other 4.8-kb/s codecs and other codecs of similar complexity.

This work was done by Thomas C. Jedrey of Caltech and Allen Gersho of Voicecraft, Inc., for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the*



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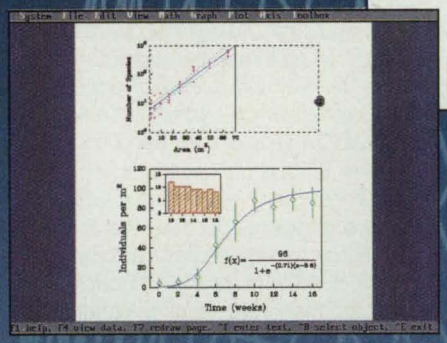

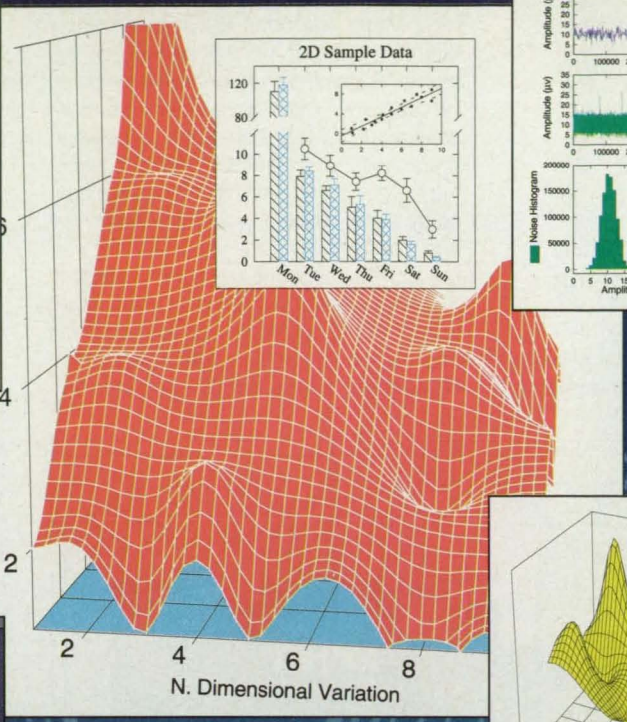

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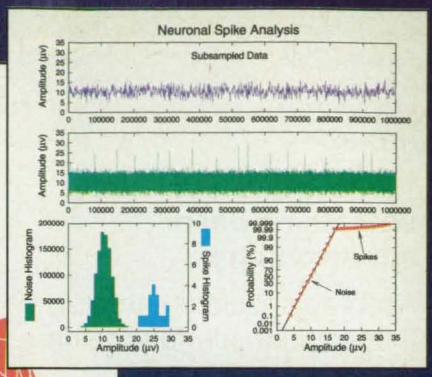

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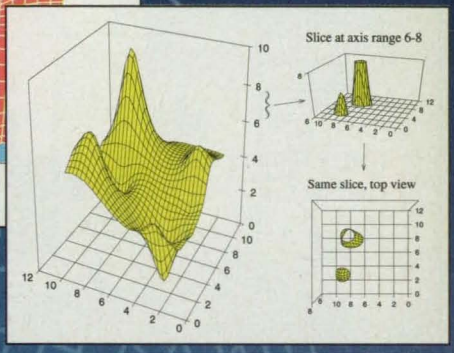

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For DOS Information Circle No. 352 **For Mac Information Circle No. 353**

report, "Performance of a Low Data Rate Speech Codec for Land-Mobile Satellite Communications," Circle 54 on the TSP Request Card.
NPO-18297

Tracking Two Spacecraft With Same-Beam Interferometry

Accuracy could be greater than in prior interferometric spacecraft tracking.

A report discusses the use of same-beam interferometry in determining the relative positions of two spacecraft, one of which could be in orbit around a distant planet (e.g., Mars), the other of which could be either in orbit or on the surface of the planet. Same-beam interferometry could be used when the angle subtended by both spacecraft, as seen from Earth, is less than the angular width of the beam of a tracking antenna. Two ground stations separated by a long baseline would simultaneously and continuously track the phases of carrier signals transmitted by both spacecraft.

These phase measurements at any given instant could be processed to determine one component of the angular separation between the spacecraft. The angular component measured would be along the projection of the baseline onto that plane, which is normal to the Earth–spacecraft line. This relative-position information could be used, for example, in computing the position or trajectory of one of the spacecraft, given the position or trajectory of the other spacecraft, which could have been determined previously from Doppler measurements. Alternatively or in addition, the phase information obtained by same-beam interferometry could be processed, along with Doppler measurements and a mathematical model of the dynamics, in a joint computation of the orbits of both spacecraft.

Same-beam interferometry would be similar, in some respects, to delta differential one-way range (ΔDOR) measurements of the position of one spacecraft. In ΔDOR, the antennas are aimed alternately at a single spacecraft, then at an angularly nearby quasar. When the antennas are aimed at the spacecraft, the group delay is determined by use of tones spaced about the carrier frequency. The quasar observations are used to calibrate the clocks at the ground stations and to cancel out some common-mode errors. Typically, the accuracy of ΔDOR is about 30 nanoradians.

In interferometric measurements of these types, many errors scale with the angular separations. Because the angular separation of two spacecraft in orbit would be much smaller (typically, a fraction of a milliradian) than the angular separation of a spacecraft and a quasar (typically, 10° ≈ 175 milliradians), these errors would be much smaller in same-beam interferometry. Simultaneous, continuous tracking and the use of phase rather than group delay would increase the accuracy further, resulting in an overall accuracy of about 50 picoradians; that is, about 1/600th the error of ΔDOR.

Even though same-beam interferometry would yield more-accurate results, the equipment and operations of same-beam interferometry would be similar to, but somewhat simpler than, those of ΔDOR: There would be no need to switch the antennas between different lines of sight. There would be no need for a cross-correlation of the broadband quasar signal in processing of the measurement data, and consequently the phase measurements could be extracted in real time. Furthermore, there would be no need to generate tones about the carrier signals; the carrier signals of the spacecraft telemetry transmitters would suffice.

This work was done by William M. Folkner and James S. Border of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Orbiter-Orbiter and Orbiter-Lander Tracking Using Same-Beam Interferometry," Circle 101 on the TSP Request Card.*
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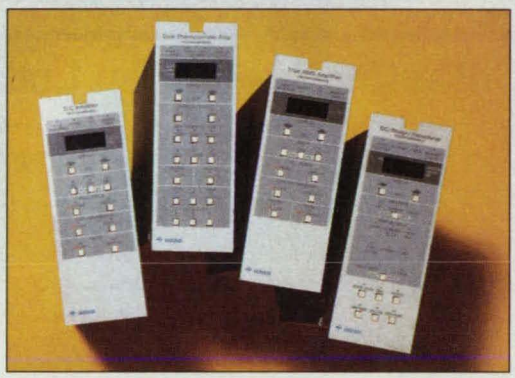

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For More Information Circle No. 484

Apparatus for Tests of Embrittlement by Hydrogen

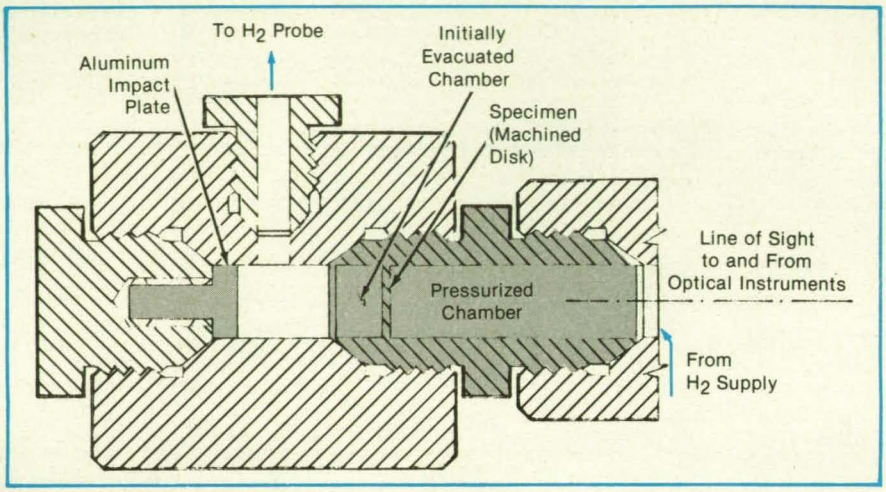
Disk specimens can be monitored in more-realistic tests.

Lyndon B. Johnson Space Center, Houston, Texas

A test apparatus exposes disk specimens to hydrogen in a controlled, repeatable way that simulates conditions in use. A specimen can be viewed from outside the apparatus, so that optical measurements can be made during tests. For example, holographic interferometry can be used to measure extremely small deflections of the specimen in real time to help researchers understand the effects of corrosion and embrittlement by hydrogen. In addition, the chamber can be used in measuring the amount of hydrogen that passes through the specimen.

Each specimen is a thin disk that separates high-pressure hydrogen from an initially evacuated chamber (see figure). The pressure sets up a minute flow of hydrogen molecules through the disk. After about 24 hours, the concentration of hydrogen on the vacuum side is sufficient to be measured by a hydrogen probe.

The apparatus thus replicates those aspects of service environments that are relevant to embrittlement by hydrogen in such equipment as storage tanks, valves, and fluid-handling components that contain hydrogen at high absolute or gauge pressure. In such a situation, the hydrogen inside can permeate the stressed material and produce a gradient of concentration as the hydrogen diffuses through the material to the low-pressure side.



The **Disk Specimen** constitutes a thin wall between the pressure and vacuum chambers. The test proceeds until the hydrogen weakens the disk enough that it ruptures. The aluminum impact plate absorbs debris from the ruptured disk.

This work was done by Rollin C. Christianson and Peter P. Lycou of Lockheed Engineering and Sciences Co. for **Johnson Space Center**. *For further information, Circle 63 on the TSP Request Card. MSC-21822*

Detecting Hydrogen Leaking Into a Purged Cavity

The composition of an H_2/He mixture would be estimated from measured pressure, density, and temperature.

John F. Kennedy Space Center, Florida

The hydrogen content of a mixture of hydrogen and helium gases would be computed from measurements of the pressure, density, and temperature of the mixture, according to a proposal. This method of determining the composition of a two-gas mixture is not new, but the particular application and method of implementation may be of interest. In this application, the purpose is to estimate the size of a leak of combustible gas into a cavity purged by a pressurized inert gas (see figure).

It is not assumed that there is enough time for the leaking and purging gases to mix perfectly down to the molecular level before the measurements are taken. However, it is assumed that the gases come to thermal equilibrium quickly and that the gross properties indicated by the pressure, density, and temperature sensors quickly reach values representative of thorough mixing. For the purpose of determining the composition, it is assumed that the pressure (P), temperature (T), and density (ρ) of the gas mixture are given by the real-gas equation

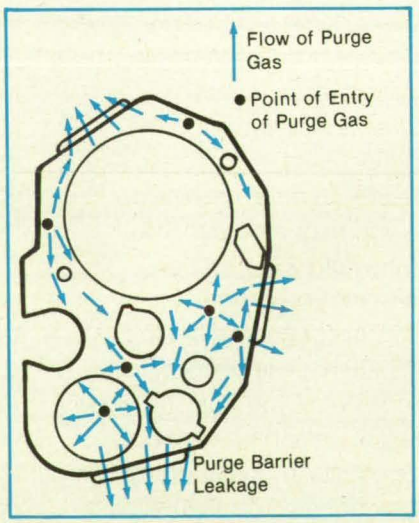
$$P = \mu R \rho T$$

where μ is a compressibility factor that represents the deviation from the ideal gas law, and R is the real-gas constant (approximately equal to the ideal-gas constant) for the specific gas.

The estimation of the composition of the gas would then be straightforward. First, one would compute μR from the measured values of P, ρ, and T:

$$\mu R = P/\rho T$$

Then one would compute the mole fractions of the two gases by interpolation in tables of the μR of each gas as a function of P and T. Of course, the tables could be



Hydrogen Can Leak Into a Cavity (in this case, a propellant umbilical cavity on the Space Shuttle). The cavity is purged with helium. The problem is to estimate the hydrogen content of the cavity and, concomitantly, the rate of leakage of hydrogen.

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For More Information Circle No. 477

stored in computer memory so that the calculations could be performed quickly. A simple leak-detection algorithm could also estimate the rate of leakage from the size of increase in the mole fractions of hydrogen measured at subsequent sampling intervals.

This work was done by William M. Stinson of **Kennedy Space Center**. *For further information, Circle 12 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Kennedy Space Center [see page 30]. Refer to KSC-11542.

Modulating Concentration of Hydrazine Vapor To Aid Detection

Modulation facilitates identification of signal in output of photoionization detector.

John F. Kennedy Space Center, Florida

Three novel techniques — flow modulation, filament modulation, and reactive-filter modulation — have been developed to obtain a selective response to hydrazine or to methyl hydrazines from a photoionization detector. These techniques, which could be implemented in portable selective hydrazine detectors, would be useful where continuous or rapid, repetitive quantitative measurements of concentrations of vapors of these toxic substances are required.

In addition to its use as a rocket fuel, hydrazine is commonly used in powerplants as an anticorrosive additive; it is also used as a precursor in synthesizing agricultural chemicals. Normally, a photoionization detector would be unable to distinguish between, say, cyclohexane (ionization potential = 9.88 eV) and monomethyl hydrazine (ionization potential = 9.8 eV). For this reason, concentrations of vapors of hydrazine and the methyl hydrazines are commonly measured by use of photoionization detectors in conjunction with chromatographic columns that separate the components of gaseous samples; the disadvantage of this procedure is that chromatographic separation takes a significant amount of time and is expensive.

The three modulation techniques make it possible to measure the concentration of gaseous hydrazines in the presence of such other gases as cyclohexane, chlorofluorocarbons, and ammonia. The flow-modulation technique is based on the fact that hydrazine is so reactive and unstable that as a sample of gas containing hydrazine is pumped from an inlet port to a sensor, some of the hydrazine vapor is lost. The amount lost depends on the rate of flow, which determines how long it takes the sample to reach the sensor. Such other compounds as cyclohexane are not as reactive, and so that component of the output of the sensor attributable to such compounds does not depend strongly on the rate of flow. One can vary the flow to make the hydrazine component of the output vary, thereby making it possible to determine the concentrations of hydrazine and cyclohexane in the sample. Hydrazine can also be distinguished from many other commonly present compounds by this technique. A mathematical model of this technique has been developed, and experiments have been performed to gather data to validate the model.

The filament-modulation technique is based on the fact that when the sample gas is in contact with a catalytic filament heated to several hundred degrees Cel-

Low Profile 12-W DC/DC Converters

The AHF 2800 series of DC/DC converters feature single or dual outputs over the full military temperature range. No derating in output power is required, making them suitable for use in rugged military applications. The low profile, small outline package is ideally suited to the tight board space requirements of many industrial and aerospace applications. Designed for nominal 28 VDC inputs, this family of converters meets all the requirements of MIL-STD-704D.

The proprietary magnetic feedback circuit provides for an extremely wide bandwidth control loop with a high phase margin. These converters are manufactured in a facility fully qualified to MIL-STD-1772. Two temperature ranges and screening grades are available to satisfy a wide range of requirements.

For More Information Circle No. 561

Low Profile 15-W DC/DC Converters

The new AHV 2800 series of 15W DC/DC converters features high power densities and ruggedized low-profile packages only 0.405 inches high. They are available in single, dual and triple output models and are fully compliant with MIL-STD-704 (A-E), MIL-STD-883 and MIL-H-38534. All AHV 2800 DC/DC converters withstand the 80-Volt surge requirement of MIL-STD-704A and operate over the full military temperature range of -55°C to +125°C with no derating of power output. These devices all have nominal 28 VDC inputs and operate over a 16 VDC—40 VDC range. The AHV 2800 series feedback design is impervious to temperature, radiation, ageing or variations in manufacture. The unique circuitry provides high control loop gain, high phase margin, and an extremely wide bandwith.

For More Information Circle No. 558

Triple Output 30-W DC/DC Converter

The ATR 2815T triple output DC/DC converter provides 30 watts of output power over the full military temperature range with no derating. This device is pin compatible with ATO series converters but offers twice the maximum output power in a lower profile package. A custom CMOS ASIC pulse width modulator and a patented magnetic feedback circuit reduce circuit complexity and enhance reliability. This converter provides 500-Volt input to output isolation and operates in a highly efficient single forward mode.

The advanced design features an extremely wide bandwidth control loop with high gain and phase margin. The control loop is compensated to provide optimum performance over the full military temperature range and over the 16 to 40-Volt input voltage range.

For More Information Circle No. 557

High-power 40-W DC/DC Converter

The AFW 2805S hybrid DC/DC converter features high power density and full military temperature range operation without output power derating. The advanced feedback design provides fast loop response for superior line and load transient characteristics and offers greater reliability than devices incorporating optical feedback circuits. The basic circuit topology is a push-pull configuration operating at a nominal switching frequency of 500Khz.

This device is designed to meet MIL-STD-704A input requirements offering full performance over a 16- to 50-Volt input range and operating at 80 Volts for 100 milliseconds or 100 volts for up to 5 milliseconds. The AFW 2805S is packaged in a rugged parallel seam welded steel case using ceramic feedthrough pins to assure true long term hermeticity.

For More Information Circle No. 559

Space Application DC/DC Converters

Advanced Analog's high-performance DC/DC converters are now being shipped for mission-critical space applications. To meet space requirements, proven radiation-hardened components are used in all necessary areas, such as the custom integrated circuits and power MOSFETs. And, because the magnetic pulse feedback circuits do not use opto-couplers or generate spurious RF energy, they are unaffected by time, temperature or radiation. These converters are all implemented using thick film hybrid technology and are fully certified and qualified to MIL-STD-883.

For More Information Circle No. 560

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sius, the hydrazine in the sample reacts, forming nitrogen and water vapor, neither of which is detected directly in a photoionization detector equipped with a lamp of either of the commonly-used 9.6- or 10.2-eV types. Therefore, if a sample that contains monomethyl hydrazine is passed through a chamber that contains such a filament on the way to the photoionization detector, the output of the detector is reduced when the filament is heated. More-stable compounds like cyclohexane, chlorofluorocarbons, and ammonia do not react significantly at the temperature of the heated filament and thus are unaffected by the filament. Thus, the change in the signal (modulation) when the sample alternately passes through or bypasses the filament chamber is an indication of the concentration of monomethyl hydrazine in the sample gas.

The reactive-filter-modulation technique is based on the fact that monomethyl hydrazine is a strongly basic compound, whereas many of the common interferant compounds are not basic, or at least are not as basic as monomethyl hydrazine is. By passing a sample gas stream through an acidic filter of the correct pH, it is possible to remove the monomethyl hydrazine from the stream. Such interferant gases as chlorofluorocarbons, cyclohexane, and carbon dioxide are not affected by the filter. The sample gas stream is made to pass alternately through the filter, then bypass the filter, thereby imparting modulation to the output of a photoionization detector. The amplitude of the modulation indicates the concentration of monomethyl hydrazine.

All three techniques produce a modulated signal, the amplitude and phase of which indicate the amount of hydrazine, monomethyl hydrazine, or 1,1-dimethyl hydrazine present in the mixture. If the amplitude of the modulated signal is zero, then no hydrazines are present. Inversely, if the modulated signal is not zero, then a hydrazine is present in the sample. In comparison with unmodulated signals, modulated signals are more stable and have greater signal-to-noise ratios. The modulation techniques can also be used with such other detectors as electrochemical cells.

This work was done by Joseph R. Stetter and G. Jordan Maclay of Transducer Research, Inc., for **Kennedy Space Center**. *For further information, Circle 39 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Kennedy Space Center [see page 30]. Refer to KSC-11520.

Sparsely Sampled Phase-Insensitive Ultrasonic Transducer Arrays

Three methods reduce errors in computations of shapes of ultrasonic beams.

Langley Research Center, Hampton, Virginia

Phase cancellation at a piezoelectric receiving transducer is an instrumental effect that arises because the voltage generated by the receiving element is proportional to the integral of the pressure over its aperture. Although this is the same effect that yields the desirable directional characteristics of piezoelectric transducers, under some experimental conditions phase cancellation results in quantitative errors in estimates of the energies in ultrasonic fields.

Three methods of interpretation of the outputs from a sparsely sampled two-dimensional array of receiving ultrasonic transducers used in transmission experiments have been investigated. These methods are (1) description of a sampled beam in terms of the first few spatial moments of the sampled distribution of energy, (2) the use of a signal-dependent cutoff to limit the extent of the effective receiver aperture, and (3) the use of spatial interpolation to increase the apparent density of sampling during computation.

Most of the energy in a typical transmitted ultrasonic field is concentrated within a main lobe, surrounded by sidelobes of smaller amplitude. The essential features of a transmitted beam of ultrasound may thus be described by the two-dimensional moments of the spatial distribution of energy sampled across a receiving aperture. An estimate of the total energy at the receiving array is obtained from the zeroth-order moment, the centroid of the energy distribution is determined from the first- and zeroth-order moments, and a measure of half width of the beam is obtained from the moments of second and lower order. These parameters based on moments provide additional information about the beam that would be lost in the case of a single-element receiver. Further, because the energy from each element is used in the calculation, the moments are inherently insensitive to phase.

Such a computation applies a heavier weight to noise that lies away from the main lobe of the transmitted beam. Moments computed under these conditions may be difficult to interpret because of the influence of the noise. Therefore, it may be desirable to limit the computation to the main lobe.

One method is to use an effective aperture smaller than the total sampled aperture. In this method, moments are computed by use of only those values that lie above a specified fraction of the peak value measured within the total aperture of the array. Thus, in effect, one allows the main lobe to determine the shape, size, and location of the effective aperture used in the computation of moments. This method excludes, in a consistent manner, smaller signals in favor of the larger signals in the main lobe.

According to sampling theory, if a band-limited function is sampled at a rate faster than twice the highest frequency component present in the function, the function can be reconstructed by interpolation. The lateral shape of the far field of a transmitting transducer is a Fourier transform of the aperture. For a spatially limited transmitter, this field is spatially band-limited. Thus, with adequate spatial sampling, the full field distribution can be reconstructed.

Results show that a sparsely sampled array of small-diameter transducer elements can be employed to characterize the main features of a transmitted ultrasonic beam. The first few moments of the distribution of energy sampled by such an array yield a phase-insensitive description of the width, the centroid, and the total energy content of the main lobe. These characteristic parameters can be computed with improved accuracy by use of spatial interpolation to increase the effective spatial sampling rate of the data and by then applying a signal-dependent cutoff in which only values above a given fraction of the peak value are used in computing the moments. With a cutoff chosen above the level of any sidelobes and sufficiently above the level of noise, this approach provides automatic correction for far-field diffraction effects. Interpolation provides a possible means for detecting very small shifts of the beam or very small changes in the width of the beam.

The development of this method significantly enhances understanding of the characterization of beams with data from signal-dependent apertures and spatial interpolation. Because the underlying concept encompasses most applications that involve finite-aperture transducers, potential for widespread application is assured.

This work was done by Patrick H. Johnston of **Langley Research Center**. *For further information, Circle 30 on the TSP Request Card.*
LAR-14302

Piezoelectric Measurement of Bulk Modulus

Piezoelectric current decreases as the constraint offered by the material increases.

Marshall Space Flight Center, Alabama

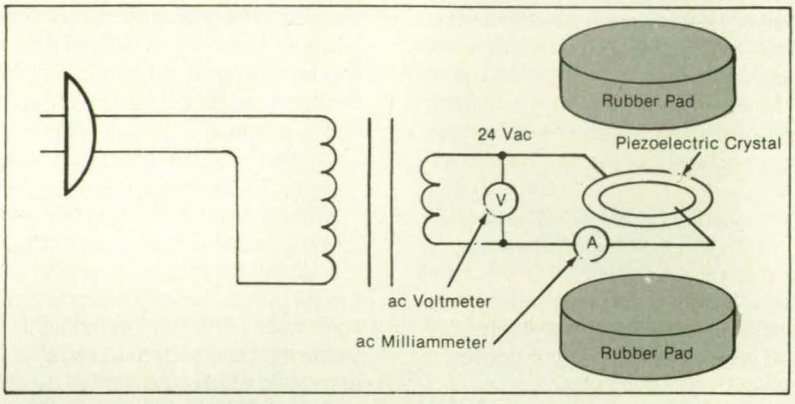
In a proposed method of measuring the bulk modulus of elasticity of an elastomeric material, piezoelectric crystals would be embedded in the material. The crystals would be of various sizes and would be energized by an alternating voltage. The method is based on the fact that (1) when a piezoelectric crystal is unconstrained, most of the energy conveyed to it by applying an electric potential goes into distortion of the crystal, but (2) the crystal generates a back electromotive force, the amount of which increases with the degree to which the crystal is constrained. In the proposed application, the degree of constraint would depend, in turn, on the bulk modulus of elasticity of the material. The power consumed by the crystals would thus be a measure of the modulus.

The concept was demonstrated in a test cell in which a piezoelectric crystal could be mounted either unconstrained or else between two rubber pads and connected as though it were the actuator in a loudspeaker. The 1-in. (2.54-cm)-diameter crystal was excited with 24 Vac at 60 Hz. When the crystal was unconstrained, it drew a current of 0.8 mA. When the crystal was constrained between the rubber pads, the current fell to 0.65 mA.

The low current, minimal heating, and absence of arcing may make the technique suitable for measurement of the bulk moduli of elasticity of flammable or explosive rubbery materials; e.g., adhesives and propellants. (The voltages and currents needed to excite the crystals are well within the ranges permitted in solid-propellant rocket motors.) New experiments with multiple crystals of various diameters are under development.

This work was done by Barry L. Butler of Science Applications International Co. for **Marshall Space Flight Center**. *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 30]. Refer to MFS-28617.



In the **Demonstration Cell**, a low ac voltage was impressed on a piezoelectric crystal. The current fell when the crystal was constrained between the rubber pads.

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Estimation of Ocean-Surface Winds From Seasat Data

A newer geophysical model produces more-accurate and more-complete estimates.

A report discusses the performance of a recently developed method of estimating the mesoscale (over distances of hundreds to thousands of kilometers) near-surface winds over the ocean from normalized cross sections for radar backscatter from the surface of the ocean. The method is based on a geophysical model that is, in turn, based on the geostrophic approximation and upon simplistic assumptions about the divergence and vorticity of the wind field, but that also includes nongeostrophic winds. This method is compared with an older method.

In the newer method, the parameters of the model are estimated from the radar backscatter via a maximum-likelihood approach. An objective function based on a log-likelihood function is computed from the scatterometer measurements. The set of values of parameters that minimizes the objective function is deemed to be the most likely estimate of the parameters, and these values are inserted in the model and used to compute the wind field. The model uses all available scatterometer measurements from sampling points across the entire radar swath to estimate the wind at any given point, and it yields an estimate of the wind vector at every sampling point in the swath — even at points where scatterometer measurements are missing.

In contrast, the older method is based on a pointwise approach, in which the measurements pertaining to each sampling point are used to estimate the wind at that point only. Furthermore, the pointwise approach yields nonunique estimates of the wind vector at each point. Thus, the wind fields estimated by the older method can include gaps (including gaps at the edges and consequent loss of swath) and ambiguities, and further processing by use of dealiasing techniques is needed to resolve the ambiguities. Because the newer method takes advantage of the inherent correlation in the wind field over the swath, it is more tolerant of noise in the scatterometer measurements than is the older method, and the accuracy of the estimates obtained by the newer method deteriorates gradually as the signal-to-noise ratio of the measurements is reduced.

The newer and older methods were tested by using them to process simulated and real Seasat backscatter measurements. The results confirm that the newer method yields more-accurate estimates of the wind field, fewer gaps, and wider swaths.

This work was done by David G. Long of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Model-Based Wind Estimation Using Seasat Scatterometer Measurements," Circle 45 on the TSP Request Card.*
NPO-18260

Mass-Transport Properties in Growth of Crystals From Vapors

The $GeSe/GeI_4$ and the $Hg_{0.8}Cd_{0.2}Te/HgI_2$ systems were studied.

A brief report summarizes the results of experimental and theoretical studies of mass-transport properties of the $GeSe/GeI_4$ and $Hg_{0.8}Cd_{0.2}Te$ systems in connection with the growth of crystals in closed ampoules. The primary emphasis in these studies was on thermochemical analyses,

on the development of mathematical models to predict diffusion-limited mass transport, and on the comparison of theoretically predicted with experimental fluxes. The results can be applied to the design, preparation, performance, and analysis of crystal-growth experiments of semiconducting materials on Earth and in outer space.

Systematic mass-transport studies of the GeSe/GeI_4 system in the absence and presence of inert gas demonstrated the existence of diffusion boundary layers under all transport modes in closed ampoules; the thicknesses of the boundary layers varied with the pressures of the compounds being transported. These observations are generally consistent with estimated relevant fluid-dynamic parameters of the respective gas mixtures. This work also demonstrated the significant effects of the modes of transport (diffusive-convective and convective flows) on the crystalline structures under otherwise-the-same experimental conditions (same mass-transport rates).

Mass-transport-rate studies of the GeSe/GeI_4 system as a function of orientation of the gradient of density in the gravitational field demonstrated the effects of convection on the mass flux of this system. In addition, local temperature instabilities of the vapor phase were observed even under vertical, stabilizing conditions. A computational model based on a stoichiometric transport reaction and process and on the absence of a second condensed phase was developed for the GeSe/GeI_4 system. In agreement with experimental data, the model predicts that sublimation dominates transport at lower pressures and chemical-vapor transport increases at higher pressures. Within the boundary conditions specified, the basic model is generally applicable to other transport systems.

On the basis of a quantitative thermodynamic analysis of the inherent solid-phase/gas-phase reactions of the $Hg_{0.8}Cd_{0.2}Te$/HgI_2 system, a first-order computational model of transport was developed to predict the mass-transport rates for diffusion-limited transport conditions. The close agreement between theoretical and experimental mass fluxes for different pressures and different source-material compositions confirms the thermochemical analysis and computational model and indicates that the model could be used to study mass-transport phenomena of this and other ternary, alloy-type vapor-transport systems. The model has been extended to predict the mass flux and overall composition of transport products of the $Hg_{0.8}Cd_{0.2}Te$ transport system.

This report was written by H. Wiedemeier of Rensselaer Polytechnic Institute for **Marshall Space Flight Center**. *To obtain a copy of the report, "Fluid Dynamics and Thermodynamics of Vapor Phase Crystal Growth," Circle 6 on the TSP Request Card. MFS-26119*

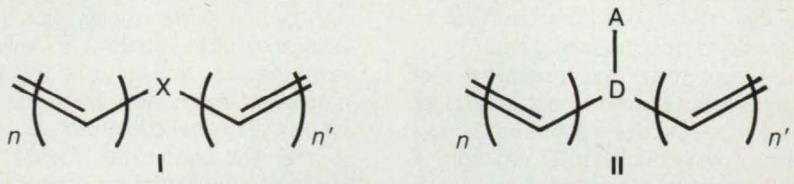
Enhancing the Hyperpolarizabilities of Finite Polyenes

Hyperpolarizabilities, and thereby optical properties, would be switchable.

NASA's Jet Propulsion Laboratory, Pasadena, California

Quantum-mechanical calculations provide the theoretical basis of an improved strategy for designing finite polyenes that would have optical properties useful in optical digital communications and optical processing of data. Such highly conjugated organic polymers as the finite polyenes typically have large nonresonant electronic susceptibilities, which give rise to unusual optical properties. The improved strategy for exploiting these properties is to (1) enhance molecular hyperpolarizabilities by introducing "defect" quantum-mechanical states and (2) produce molecules that could be switched photochemically or electrochemically between states characterized by considerably different second molecular hyperpolarizabilities.

Heretofore, the relatively limited strategy for increasing the second molecular hyperpolarizability of a material has been to increase the widths of the valence and conduction electron-energy bands of the material and to decrease the gap between these bands. In the improved strategy, conjugation and/or substitution defects, which could be electrically neutral or charged dopant or impurity atoms or groups thereof, would be incorporated into a finite polyene, possibly by (1) light doping of a conjugated polymer (an irreversible process) or (2) synthesis of a conjugated polymer that would contain, in conjugation with the polymer, a photoexcitable species (electron donor) from which an electron could be transferred reversibly to an acceptor (see figure). These defects would introduce midgap quantum-mechanical states that would, in turn, influence the magnitude and the sign of the second molecular hyperpolarizabilities.



Notes: 1. n and n' are integers.
2. X can be a carbon, metal, or other neutral or charged atom.
3. D is an electron donor.
4. A is an electron acceptor.

Defects in Finite Polyenes would alter their second molecular hyperpolarizabilities. Transient large second hyperpolarizabilities should be attainable in molecules of structure II.

Thus far, lightly doped finite polyenes in which the defects would be located at the middles of the molecular chains ($n = n'$ in structure I of the figure) have been analyzed quantitatively. By use of a one-electron tight-binding approximation, the dependence of the second molecular hyperpolarizabilities upon the occupancies and energies of the defect states were calculated. The defects were found to cause significant decreases or increases by impeding localization of charge or creating partly filled bands (mimicking the one-band limit), respectively.

The results of the analysis also suggest that materials that have transient large second hyperpolarizabilities might be made by use of molecules, like those of structure II in the figure, that have charge-transfer excited states with long lifetimes.

Details of this work are reported in the *Journal of Physical Chemistry*, vol. 93, pages 3915 et seq. (1989) and in U.S. Patent No. 5,011,907.

This work was done by David N. Beratan of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 56 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 30]. Refer to NPO-17633.

Bulk Electro-Optical Polymer Component

The polymer could serve in high-voltage sensors and laser-beam modulators.

NASA's Jet Propulsion Laboratory, Pasadena, California

An electro-optical polymer of relatively low cost has been formed as a bulk specimen (5 by 7 by 7 mm) from the azo dye 4-(4-nitrophenylazo)-N-ethyl, N-2-hydroxyethylaniline (also known as Disperse Red 1 or DR1) and a transparent epoxy. This polymer may be more stable, in the long term, than prior electro-optical polymers based on DR1 and poly(methylmethacrylate) have been. If the polymer were sandwiched between electrodes, it could provide direct measurement of high voltage via the electro-optical effect. In addition, it has significant nonlinear optical properties. This material may be useful in microelectronics, micro-optics, integrated optics, and testing of materials.

In the preparation of the specimen, purified DR1 was dissolved in EPO-TEK 301-2 epoxy resin at a concentration of 5 weight percent. The amine hardener supplied with the resin was added. The epoxy mixture was poured into a mold equipped with top and bottom electrodes, both of which made contact with the mixture. The epoxy mixture was partially cured at room temperature in a vacuum chamber for 15 to 20 h. The mold was then heated in an oil bath to accelerate the cure.

When the temperature in the oil bath reached about 40 °C, a process of poling — that is, alignment of the dye molecules in an electric field — was begun. (This alignment is a prerequisite for the electro-optical effect.) As the specimen was heated above 40 °C, voltage from a 100-kV dc high voltage supply was gradually applied across the specimen via the electrodes. As this was done,

the current was monitored and the voltage adjusted so that the current did not exceed a preset limit of 10 μA.

When the temperature reached 80 °C, it was then kept constant for a while; at that temperature, the curing time of the epoxy is only 1½ h. The voltage was then gradually increased until the maximum electric poling field of approximately 120 kV/cm was reached; the current simultaneously decreased to its minimum of a few μA or less, indicating that the specimen was almost completely cured. The system was then cooled to room temperature while maintaining the poling field.

The specimen thus prepared was cleaned and mounted to act as a laser modulator. A circularly polarized 0.7-mW beam of wavelength 1,150 nm from a He/Ne laser was passed through the specimen, and through a polarizer rotated 45° relative to the fast optical axis of the specimen. The voltage applied to the electrodes, acting via the electro-optical effect, changed the polarization from circular to elliptical, thereby changing the power transmitted through the polarizer. The transmitted beam was measured by an optical-power meter based on a Ge photodiode. With this arrangement, a sinusoidal voltage of 4 kV at a frequency of 60 Hz was applied to the electrodes, the dc level of the transmitted beam was measured by the power meter, and the ac modulation of the beam was viewed on an oscilloscope and measured by a lock-in amplifier. From these measurements, the electro-optical coefficient, r_{33}, of the polymer was found to be 1.7×10^{-14} m/V. It was also found that the polymer could withstand electric fields up to 120 kV/cm.

This work was done by Allan Gottsche, Joseph W. Perry, and Kelly J. Perry of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 102 on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Edward Ansell
Director of Patents and Licensing
Mail Stop 305-6
California Institute of Technology
1201 East California Boulevard
Pasadena, CA 91125

Refer to NPO-18207, volume and number of this NASA Tech Briefs *issue, and the page number.*

Fatigue in Continuous-Fiber/Metal-Matrix Composites

Techniques for meaningful tests to detect and quantify fatigue damage are reviewed.

Langley Research Center, Hampton, Virginia

A report describes various experimental approaches to the quantification of fatigue damage in metal-matrix composites (MMC's). The report discusses a number of examples of the development of damage and of failure along with some associated analytical models of the behavior of an MMC.

The use of metal-matrix composites reinforced with continuous fibers is projected for high-temperature, stiffness-critical parts that will be subjected to cyclic loads. However, fatigue of a MMC can be quite complex. The matrix, because of its relatively high strength and stiffness compared to those of the fiber, plays a very active role compared to that of a polymer matrix.

The objectives of the report are twofold. The first objective is to present experimental procedures and techniques for conducting meaningful fatigue tests to detect and quantify fatigue damage in MMC's. These techniques include interpretation of stress-vs.-strain responses, acid etching of the matrix, edge replicas of the specimen under load, radiography, and micrographs of the failure surfaces. In addition, the report shows how the loss of stiffness in continuous-fiber-reinforced MMC's can be a useful parameter for detecting the initiation and accumulation of fatigue damage.

The second objective is to present numerous examples of how fatigue damage can be initiated and grow in various MMC's. Depending on the relative fatigue behavior of the fiber and matrix and on the properties of the interfaces between fibers and the matrix, the modes of failure of MMC's can be grouped into four categories: (1) matrix-dominated, (2) fiber-dominated, (3) self-similar growth of damage, and (4) fiber/matrix interfacial failures. These four types of damage are discussed and illustrated by examples with emphasis on the fatigue of unnotched laminates.

Matrix-dominated damage occurs if the matrix material has a lower fatigue endurance strain range than does the fiber. The result is the development of matrix cracks that can cause significant losses in stiffness in laminates with off-axis plies.

Fiber-dominated damage occurs if the fiber has a lower fatigue endurance strain range than does the matrix material. In this case, numerous fiber breaks may occur within the laminate, yet the stiffness may be relatively unaffected. This type of damage results in sudden laminate failure.

Self-similar growth of cracks can occur if the fiber and matrix materials have similar values of fatigue endurance strain ranges. The material can experience growth of cracks much like the growth of a crack in a homogeneous material.

Fiber/matrix interfaces fail if they are weaker in the transverse direction than the fiber and the matrix are. The higher the strength of the matrix material, the greater the chance of interfacial failures in the off-axis plies.

As new continuous-fiber-reinforced MMC's are developed, projections of their fatigue behavior can be made by understanding the relative strengths of the fiber, matrix, and fiber/matrix interface. This report is intended to furnish some insight into what type of fatigue damage can occur and how the damage might be quantified.

This work was done by William S. Johnson of **Langley Research Center**. *Further information may be found in NASA TM-100628 [N88-25489], "Fatigue Testing and Damage Development in Continuous Fiber Reinforced Metal Matrix Composites."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.

LAR-14384

Lightweight Protective Coatings for Titanium Alloys

Ultrathin dual barrier system provides effective protection for titanium.

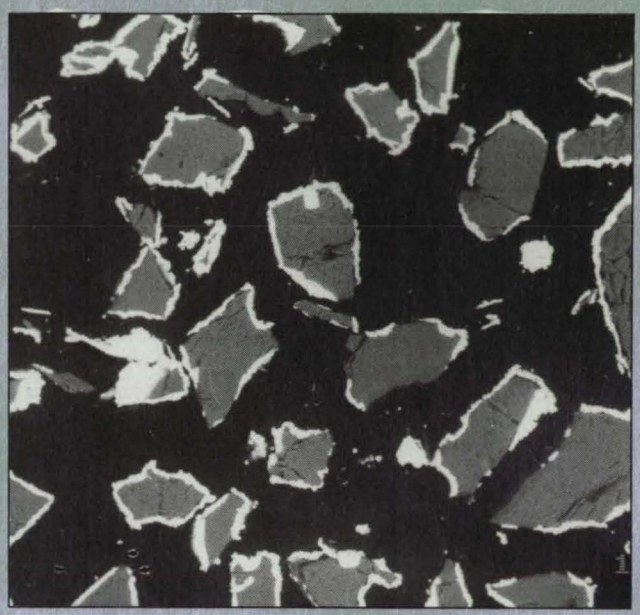
Langley Research Center, Hampton, Virginia

Titanium alloys are critically important in the aerospace industry because of their high strengths and low densities. However, the application of them is limited because they are susceptible to environmental attack: oxygen and nitrogen react vigorously with titanium alloys at high temperatures, forming surface oxides and causing solid-solution contamination of the alloys, reducing their ductilities.

Previous methods of protecting titanium alloys included coating by a variety of meth-

CHOOSE INCO COATED PRODUCTS FOR HIGH PURITY AND PREDICTABLE PROPERTIES.

Nickel Coated Graphite Powders



Nickel Coated Alumina

INCO Specialty Powder Products' development of the use of carbonyl gas coating allows deposition of nickel with very high purity and predictable properties and is uniquely suited for a variety of coated products and applications.

INCO SPP COATED PRODUCTS

Nickel combines a unique mixture of special physical, conducting and magnetic properties. The ability to deposit nickel on various substrates greatly extends the potential for the use of these properties. Coatings are being made, for example, on silica, graphite, alumina, tungsten carbide, clays and ceramics. INCO SPP has the capability to coat special substrates on a custom basis for individual users.

APPLICATIONS

New uses for INCO SPP Coated Products include conducting film technology, electronics packaging, EMI shielding, electronic detection devices, controlled heating systems, hard metals and powder metallurgy parts.

RESEARCH

INCO SPP research activities for this line of products include nickel carbonyl coated powders and other substrates. Applications include advanced products for EMI shielding, ESD, arc welding, powder metallurgy additives, and in battery technologies.

One highly interesting area of research is in the area of electronic detection. Coated products are being combined with paint for highway divider strips and as ink in bar codes for vehicle identification. This could provide an accurate measure of automobile speed on those highways. Another futuristic consideration is "computer trips for cars" using those strips and bar codes to program automotive travel and identification.

INCO SPP

INCO Specialty Powder Products is your unique resource for coated products. Our customer focused worldwide marketing service group is ready to help you with your current and future needs for coated products.

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For More Information Circle No. 652

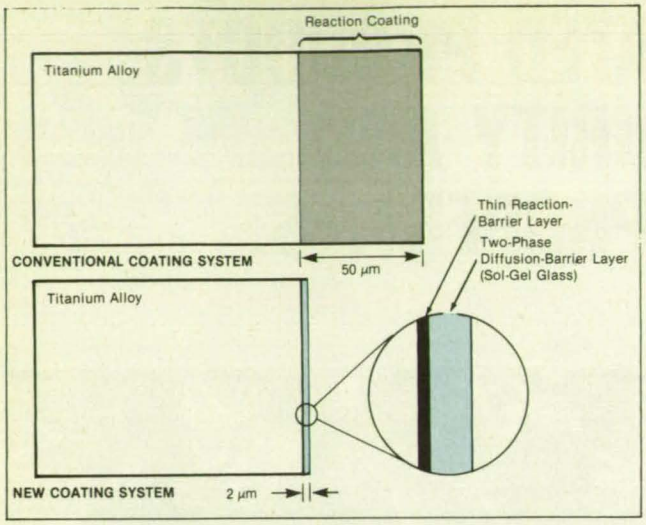


Figure 1. **Reaction-Barrier and Self-Healing Diffusion-Barrier Layers** combine to protect a titanium alloy against chemical attack by oxygen and nitrogen at high temperatures.

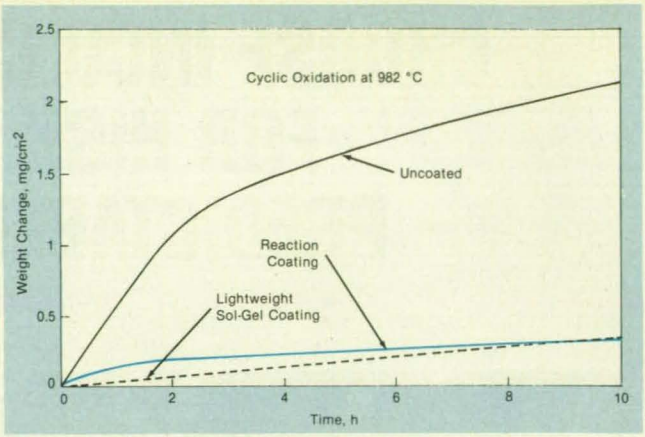


Figure 2. **Oxidation Protection of Ti-14Al-21Nb** (Wt %) alloy by a light-weight sol-gel coating equals or exceeds that of a much thicker reaction coating.

ods. For one method, the alloy is heat-treated after application of a coating compound, producing a protective reaction layer between the coating compound and the alloy. These coatings must be relatively thick (about 25 μm) to provide a substantial protection. Interactions between a coating and the underlying alloy can exert a deleterious effect on the mechanical properties of the alloy, and a thick coating can diminish or eliminate the advantage of the high strength-to-weight ratio of titanium alloys.

Therefore, a lightweight coating was developed to protect titanium and titanium aluminide alloys and titanium-matrix composite materials from attack by the environment when used at high temperatures. The protective coating is applied by sol-gel methods, and its thickness is less than 5 μm. Because of the reactivity of titanium with most materials that act as barriers against the diffusion of oxygen and nitrogen, it is necessary to provide a reaction-barrier layer to maintain separation between the titanium alloy and the diffusion-barrier layer. It is also necessary that the diffusion-barrier layer remain free of microcracks and other defects throughout its service life.

These requirements are met by a multilayer coating system: a reaction-barrier layer 1 to 2 μm thick is deposited on the titanium alloy; then a silica diffusion-barrier layer 2 to 3 μm thick is deposited on the reaction-barrier layer (see Figure 1). The reaction barrier is a compound such as yttrium-stabilized cubic zirconium oxide or barium titanate. The silica diffusion-barrier layer is a two-phase glass that consists of a silica-rich glass matrix plus dispersed frozen droplets of a magnesium phosphate glass that softens at a lower temperature.

The diffusion-barrier layer is tailored so that the droplet phase is soft at the temperature of use to promote self-healing of defects and microcracks. Thus, the reaction-barrier and diffusion-barrier layers prevent gases in the environment from attacking the titanium alloy at high temperatures.

Very promising results have been demonstrated by oxidation-protective coatings prepared by sol-gel techniques (see Figure 2). Multilayer two-phase glass coatings that are about 2 μm thick compare very favorably with commercially available intermetallic coatings that are 25 to 50 μm thick. These ultrathin coatings have the potential to multiply the life of pure titanium at 700 °C by a factor of 100. This concept can also be extended to the protection of other environmentally sensitive materials.

This work was done by Karl E. Wiedemann and Patrick J. Taylor of Analytical Services and Materials and Ronald K. Clark of **Langley Research Center**. *For further information, Circle 13 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 30]. Refer to LAR-14448.

High-Performance, Semi-Interpenetrating Polymer Network

A combination of two commercially available resins exhibits greater toughness and resistance to microcracking.

Langley Research Center, Hampton, Virginia

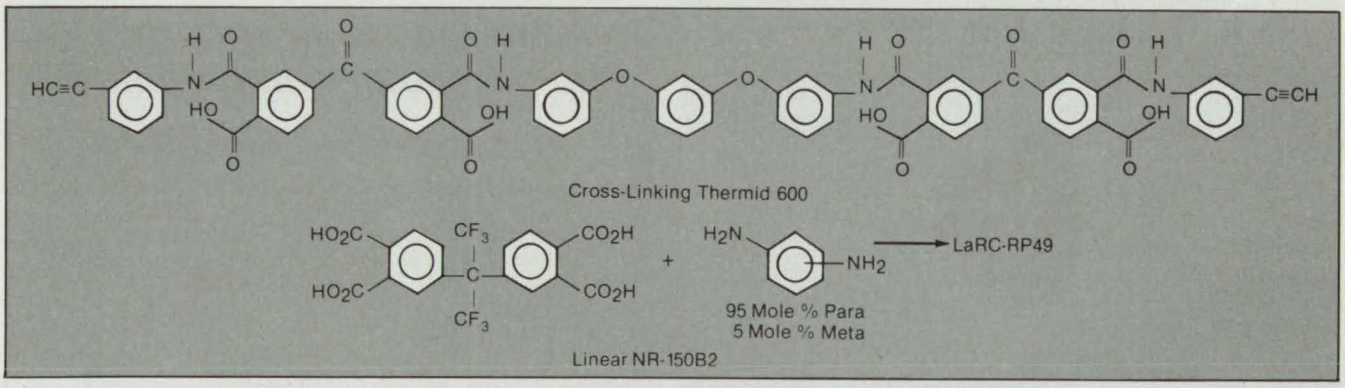
A high-performance polymer can be made by a new synthesis in which one or more easy-to-process, but brittle, thermosetting polyimides are combined with one or more tough, but difficult-to-process, linear thermoplastics to yield a semi-interpenetrating polymer network (semi-IPN) that has a combination of easy processability and high tolerance to damage. In an experiment that demonstrates this synthesis, two commercially available resins were combined to form a tough, semi-IPN called "LaRC-RP49." The first resin was a high-temperature, thermosetting resin, Thermid-600®. The second resin was a high-temperature, thermoplastic polyimide, NR-150B2®.

The figure illustrates the synthesis. In comparison with Thermid-600, LaRC-RP49 displays improvements in toughness and resistance to microcracking, but its glass-transition temperature is slightly lower. The mechanical properties of LaRC-RP49 at high temperatures suggest that NR-150B2 acts as a reinforcement at those temperatures. The results of the experiment also indicate that when a semi-IPN is used as a composite matrix, a new interface is introduced between the polymeric phases. The strength of this interface plays an important role in controlling such toughness-related properties as microcracking.

Like its semi-IPN precursors, LaRC-RP49 has potential as a high-temperature matrix resin, adhesive, and molding resin. It should be useful in the aerospace, automotive, and electronic industries.

This work was done by Ruth H. Pater, Sharon E. Lowther, Janice Y. Smith, Michelle S. Cannon, Fred M. Whitehead, and Robert M. Ely of **Langley Research Center**. *For further information, Circle 41 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 30]. Refer to LAR-14339.



LaRC-RP49 Is Synthesized from commercially available thermosetting and thermoplastic resins.

Damage-Tolerant Composites Made by Stitching Carbon Fabrics

High damage tolerance and potential low cost make these materials attractive.

Langley Research Center, Hampton, Virginia

Composite materials that consist of epoxy matrices reinforced by carbon fibers have been developed to produce aircraft structures of reduced weight. However, the structural efficiency of these composites is severely degraded by holes, notches, or damage. New, toughened composite materials tolerate damage better and exhibit greater structural efficiency, but they are considered too expensive for widespread application to commercial aircraft. Therefore, work has been conducted at NASA Langley Research Center to investigate stitching combined with resin transfer molding to make composites more tolerant of damage and potentially cost competitive with metals.

During this work, composite materials were tailored for damage tolerance by stitching layers of dry carbon fabric with closely spaced threads to provide reinforcement through the thickness. Epoxy resin was then infused into the stitched preforms, and the epoxy was cured. Various stitching patterns and thread materials (Kevlar®, carbon, and glass) were evaluated by use of flat plate specimens. Also, blade-stiffened structural elements were fabricated and tested. Tests included measurements of compression strengths of coupons with

and without holes, measurements of compression strengths of panels after impact, and tests of stiffened panels.

Tests of stitched flat laminates showed outstanding damage tolerance, excellent compression strength in notched specimens, and acceptable fatigue behavior. Stitched specimens evidenced no loss of compression strength after hundreds of temperature cycles from 200 °F (93 °C) to −65 °F (−54 °C). Strong, closely spaced threads of Kevlar®, fiberglass, or carbon were equally effective. Stitching in a single direction was as effective as was stitching in a square array in suppressing delaminations and limiting impact damage. Blade-stringer panels were successfully fabricated by use of hard tooling and resin transfer molding. A three-stringer panel demonstrated excellent postimpact compression strength.

This development is expected to be of particular interest to the aircraft and automotive industries.

This work was done by Marvin B. Dow of **Langley Research Center** *and Donald L. Smith of Planning Research Corp. For further information, Circle 50 on the TSP Request Card.*
LAR-14420

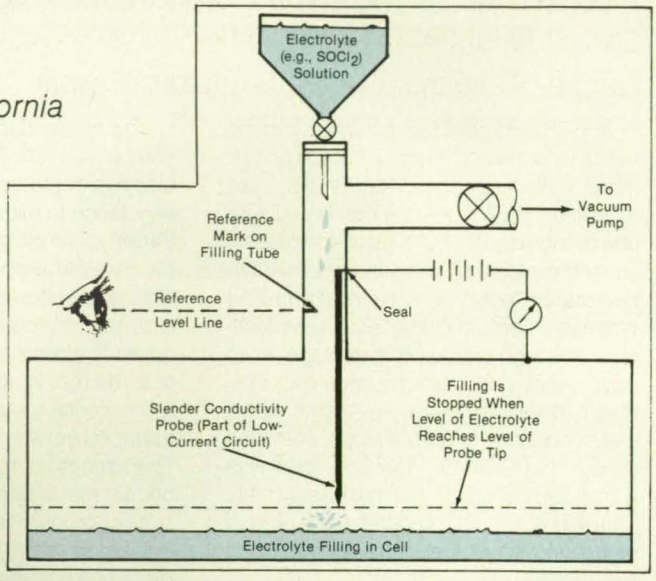
Filling Batteries Precisely With Electrolyte

Electrolyte-filled batteries would have the specified initial void volume.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed apparatus (see figure) would include a conductivity probe that would detect the arrival of a liquid filling at a specified level. The apparatus would enable the precise, rapid, and reproducible filling of electrochemical cells with electrolyte solutions to specified levels, thereby providing the specified void volumes in the cells.

Precise control of void volumes can prevent the undesirable consequences that result from void volumes that are too large or too small. The void volume of a cell affects the pressure, and, therefore, the temperature, at which the cell vent opens (to prevent explosions, for example in an Li/



This **Battery-Filling Device** would ensure that the filled cell has the specified void volume.

$SOCl_2$ cell). If the temperature is too high before venting, an explosion may occur; this can happen if the initial void volume is too large. If the initial void volume is too small, the cell can vent before its full capacity is discharged.

The cell can be designed with the proper initial void volume to avoid these extreme events. However, present manufacturing techniques — in which cells are filled with electrolyte solutions by adding amounts measured by bulk volume or bulk mass — do not control the electrolyte volume to within the necessary limits to prevent such undesirable events.

To ensure that filled cells have the specified void volume, the proposed cell-filling apparatus would include the electrolyte-level-measuring conductivity probe plus means to deliver the solution in small, periodic volumes after the bulk of the solution — an amount less than the required volume — has been delivered to the cell. Because the cross-sectional area of the cell varies very little and because the roof of the cell and the filling tube can be conveniently fixed in space by use of a cell fixture, the level of the solution in the cell can serve as a direct and sensitive control of the initial void volume.

The cell-filling procedure would be as follows:

1. Evacuate the cell.
2. Deliver the bulk of the required volume of electrolyte to the cell.
3. After allowing enough time for the absorption of the solution into the electrode stack in the cell, deliver the solution dropwise until the desired level is reached (as determined by the conductivity probe).
4. Seal the cell as in the customary procedure.

This work was done by Ralph Lutwack of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 105 on the TSP Request Card.*
NPO-17989

Molybdenum in Cathodes of Sodium/Metal Chloride Cells

Molybdenum may have some value as an active electrode material or as a current-collector material.

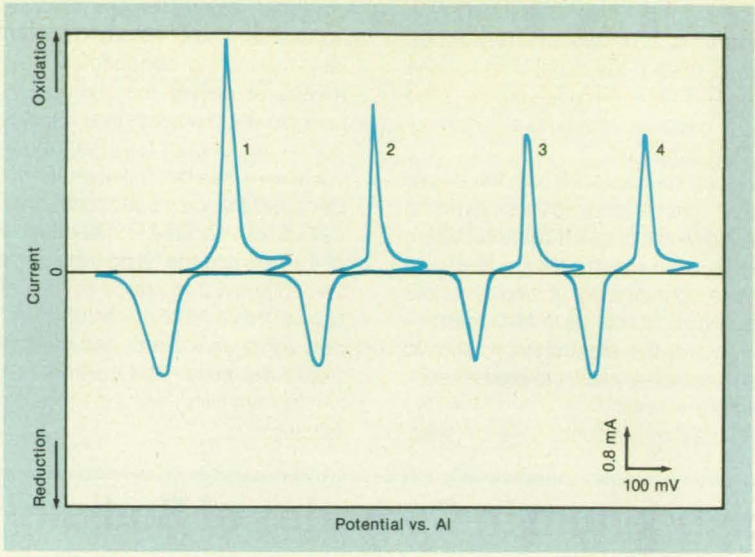
NASA's Jet Propulsion Laboratory, Pasadena, California

Cyclic voltammetric curves of molybdenum wire in $NaAlCl_4$ melt (see figure) indicate that molybdenum chloride ($MoCl_x$) might be useful as a cathode material in rechargeable sodium/metal chloride electrochemical cells. The formation of $MoCl_x$ appears to be reversible, and $MoCl_x$ appears to be insoluble in the molten $NaAlCl_4$ electrolyte. The kinetic stability apparently provided to Mo via a protective layer of the chloride formed during oxidation, combined with the higher oxidation potentials of Mo in comparison with those of Ni and Fe, enable molybdenum to be an ideal positive-current-collector/grid material in $Na/FeCl_2$ and $Na/NiCl_2$ batteries. These batteries could be used in electric vehicles, for electric-power load leveling, and in other applications that involve high energy and power densities.

The essential requirement for successful operation of a metal chloride as cathode in a sodium/metal chloride cell is its insolubility in the molten $NaAlCl_4$ electrolyte. $NiCl_2$ and $FeCl_2$ essentially meet this requirement and perform well in batteries, but other suitable metal chlorides that would have higher potentials, higher electrochemical equivalents, and higher energy densities are sought. The search may be guided by criteria that have emerged from the cyclic voltammetric responses of nickel and ferrous chlorides.

One criterion is that the cyclic voltammetric curve of the material in question should consist of sharp reversible peaks, with low oxidation currents subsequent to the peaks. In general, the dissolution of the metal electrode during oxidation is inhibited by the oxidation product deposited on the electrode. The protective nature of the oxidation product is determined by its microstructure and its chemical and electrochemical stability in the electrolyte. Low oxidation currents subsequent to peaks thus imply an insoluble oxidation product. High oxidation currents subsequent to peaks could be caused either by the formation of a porous deposit (in which case the sizes of the reduction peaks are comparable to those of the oxidation peaks) or by the solubility of the oxidation product (in which case the reduction peaks would be smaller, especially at smaller scan rates).

On the basis of these criteria, Mn, Cr, Al, Ag, Ti, Co, Mo, and V were screened as cathodes in an $NaAlCl_4$ electrolyte in a high-temperature-glass cell with concentric Ni foil as counterelectrode and highly pure aluminum as the reference electrode. Each of these metals except Mo and to some extent cobalt, failed to satisfy one or more of the criteria, but the voltammetric curves of Mo included sharp, reversible peaks that were approximately symmetrical in shape and size. More importantly, the dissolution current subsequent to the peaks was found to be rather low, imply-



These **Cyclic Voltammetric Curves** of molybdenum wire in $NaAlCl_4$ melt at 250 °C suggest an absence of solubility, as well as a high degree of reversibility, for the molybdenum chloride formed via oxidation. (The initial voltage was 997 mV vs. Al.)

ing that the oxidation product (molybdenum chloride) is insoluble in the molten $NaAlCl_4$ electrolyte, forming a nonporous film on the electrode and inhibiting further dissolution of metal. In other words, the voltammetric curves suggest an absence of solubility, as well as a high degree of reversibility, for the molybdenum chloride. Accordingly, Mo appears promising as a cathode material in Na batteries.

The oxidation and reduction peaks are located at 1,035 and 935 mV vs. Al. Because the potential of an Al reference electrode vs. Na^+/Na at 250 °C is 1.643 V, this implies that the charging and discharging voltages of an $Na/MoCl_x$ cell would be 2.68 and 2.58 V, respectively, at 250 °C. The open-circuit voltage would be ≈2.64 V at 250 °C.

This work was done by Ratnakumar V. Bugga, Alan I. Attia, and Gerald Halpert of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 66 on the TSP Request Card.*
NPO-18384

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Conditions of Directional Solidification Affect Superalloy

Microstructure and fatigue properties depend on the gradient of temperature and rate of solidification.

A report describes experiments to determine the effects of the gradient (*G*) of temperature and the rate (*R*) of solidification on the microstructure and fatigue properties of the nickel-based superalloy MAR-M246(Hf). Enhancement of the properties of this alloy would extend the lifespans of objects — including the turbopump blades of the Space Shuttle Main Engines — made from it.

Three different temperature gradients — 68, 170, and 309 °C/cm — were selected to directionally solidify the superalloy at

two different solidification rates: 5 cm/h and 30 cm/h. The specimens were then subjected to the standard heat treatment, and the resulting microstructure was metallographically examined.

The fatigue specimens were tested for high-cycle fatigue at room temperature in air with a minimum/maximum ratio of 0.4 and a maximum stress level of 125 kpsi (862 MPa). Data from the fatigue tests were then analyzed by use of the Weibull technique. This analysis showed the characteristic life at the lowest G/R to be about 10 times that at the highest G/R, but to be accompanied by less reliability.

The distances between primary dendrite arms were found to decrease with both G and R. In addition, trends in the microstructures of the carbide and γ–γ' phases were found to be related to G/R.

At the higher R, the microstructure of the carbide was found to change from small fine block to small fine script as G was increased. At the lower R, there was a coarsening, along with the appearance of large irregular block carbides, as G was increased.

There appears to be a correlation between G/R and the microstructure of the carbide. At $G/R < 10$ °C·h/cm^2, the microstructure is block; script appears at $G/R = 10.3$ °C·h/cm^2. As G/R increases from 10.3, the script carbides become coarser, and irregular blocks become more prominent. However, the total results indicate that G/R alone may be insufficient to predict the behavior of the carbides. In particular whereas small block carbides were observed in this study at the low G/R values of 2.2 and 5.7 °C·h/cm^2, there are published results from earlier experiments that indicate that block carbides form at high G/R. The distribution of temperature during directional solidification may significantly affect the microstructure of the resulting solidified material.

On the basis of the combined data on microstructure and fatigue, it appears that the small block carbide microstructure is preferable to the other microstructures in that it is associated with longer characteristic life. The predominant failure mechanism was identified as stage 1 crystallographic high-cycle fatigue; some fracture surfaces indicated failure by grain-boundary cracking, ductile overload, and surface and subsurface anomalies. Specimens with inclusions had a shorter fatigue life than did specimens of the same G and R that did not show inclusions.

These results indicate that significant improvements in fatigue properties can be derived through manipulation of the parameters of directional solidification. In particular, MAR-M246(Hf) for turbine blades should contain small, well-dispersed blocky carbide and a microstructure with small distances between dendrite arms, and preferably without eutectic phase.

This work was done by D. D. Schmidt, W. S. Alter, W. D. Hamilton, and R. A. Parr of **Marshall Space Flight Center**. *Further information may be found in NASA TM-100374 [N89-29528], "The Effects of Temperature Gradient and Growth Rate on the Morphology and Fatigue Properties of MAR-M246(Hf)."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
MFS-27231

Diamondlike Protective Coats for Infrared Windows

Experiments yield mixed results.

A report describes experiments in which four infrared-transparent window materials (fused SiO_2, Si, ZnS, and ZnSe) were coated with diamondlike carbon films. The purpose was to investigate the ability of the films to protect infrared windows against erosion by rain and wind-blown hard particles (e.g., sand). The two of these materials

(ZnS and ZnSe) that are used most often as infrared windows are soft and, therefore, especially vulnerable in severe environments. Diamondlike films were chosen as candidate protective coats because they are transparent over a broad spectral range and resist attack by chemicals, moisture, and abrasion.

In the experiments, specimens of the window materials were coated by three different ion-beam methods: (1) sputter deposition from a carbon target by use of an 8-cm argon-ion source, (2) direct deposition by a 10-cm-aperture-masked 30-cm hollow-cathode ion source with methane and butane in argon, and (3) dual-beam direct deposition by the 30-cm hollow-cathode ion source and the 8-cm argon-ion source.

In an attempt to increase the adhesion of the diamondlike films on ZnS and ZnSe, each window-material specimen was treated, prior to deposition, by one of the following techniques: (1) ion-beam cleaning, (2) ion implantation via "knock on" of thin carbon films by 100-keV nitrogen ions, (3) ion implantation with 100-keV neon and helium ions, or (4) thin, ion-beam-sputter-deposited intermediate coating with germanium or silicon.

The diamondlike films were then examined to determine hydrogen content, adherence, intrinsic stress, infrared transmittance, and ability to protect against erosion. A sand blaster with 27-μm-diameter Al_2O_3 particles was used to determine the ability of the diamondlike films to protect against erosion by wind-driven hard particles. After erosion, an infrared spectrophotometer was used to indicate the change in specular transmittance between 2.5 and 50 μm. The coated windows were also subjected to water droplets impinging at 180 m/s for exposure times up to 15 min. These specimens were qualitatively evaluated by optically viewing the pitting, microcracks, and subsurface ring cracks that resulted from the erosion.

The hydrogen-to-carbon ratio of the ion-beam-deposited films was nearly 1, while the ion-beam-sputter-deposited films had a relatively low hydrogen-to-carbon ratio, even with the addition of hydrogen gas. The compressive stresses exhibited by the deposited films did not depend on the hydrogen content, but on such other parameters as the hydrocarbon gas and the deposition technique and conditions. Elevated stresses were found in the films that were ion-beam deposited with butane or ion-beam-sputter deposited from a graphite target. This indicates that thick films with good adherence on ZnS and ZnSe could not be generated.

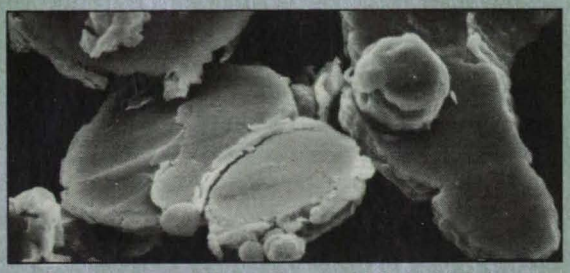
Even though the diamondlike films on fused silica exhibited adherence as good as the maximum measurable adherence of the tester, these films were not as adherent on the ZnS and ZnSe substrates. Ion beam-cleaning and ion implantation did not increase adherence. Ion implantation did, however, improve the physical hardnesses of the substrates. Intermediate coats of Ge enabled the diamondlike films to remain adherent and exhibited adherences equal to the strengths of the substrates. These intermediate Ge films caused small reductions in the infrared specular transmittances of ZnS and ZnSe at shorter wavelengths, but only a 1 percent loss occurred at a wavelength of 10 μm.

Although ion implantation plus diamondlike films did not protect the ZnS and ZnSe windows exposed to the simulated erosion by hard particles, they did improve the performance of ZnS exposed to erosion by simulated rain. The ZnS windows in which He ions were implanted and which were then coated with the intermediate germanium and the outer diamondlike layers had fewer new surface pits and a delayed start of subsurface ring cracks.

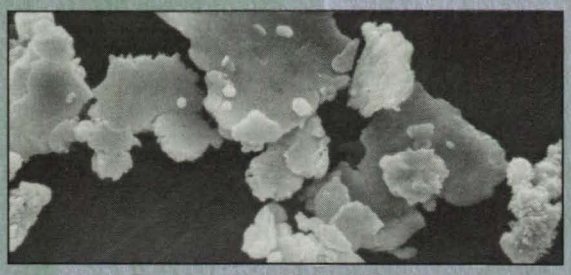
This work was done by Diane M. Swec, Bruce A. Banks, and Michael J. Mirtich of **Lewis Research Center**. *Further information may be found in NASA TM-102111 [N89-27506], "Diamondlike Carbon Protective Coatings for Optical Windows."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
LEW-15045

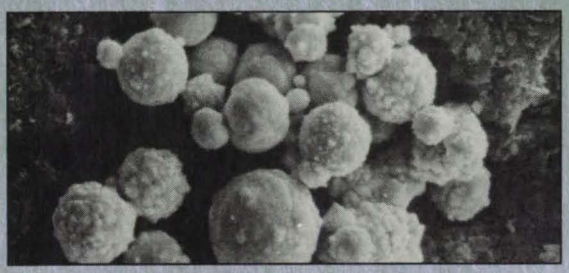
NOVAMET
CONDUCTIVE PIGMENTS



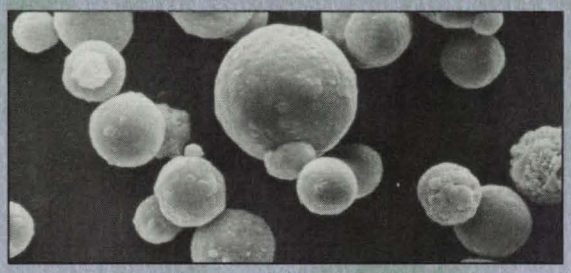
Conductive Silver Coated Nickel Flakes



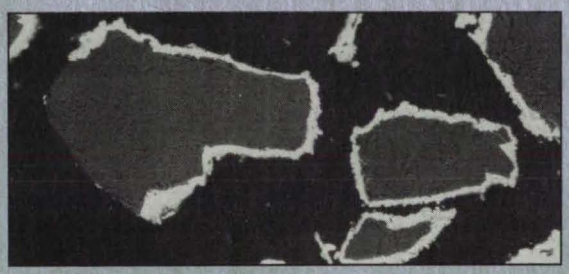
Conductive Nickel Flakes



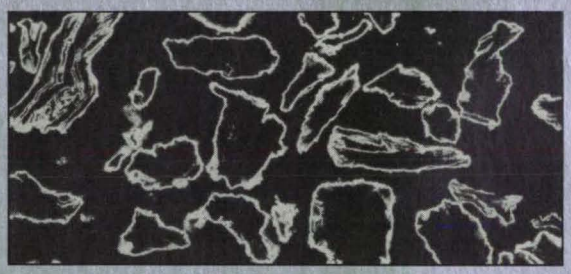
Conductive Silver Coated Nickel Spheres



Conductive Nickel Spheres



Conductive Nickel Coated Alumina



Nickel Coated Graphite

Also:

Conductive Nickel Coated Glass Frit
Conductive Nickel Coated Aluminum
Conductive Nickel Pigment 525
Conductive Silver (0.5%) Stabilized Nickel Flakes

And

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Custom Micron Separation of Nickel Powders
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For More Information Circle No. 635

Computer Programs

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Computer Programs

These programs may be obtained at a very reasonable cost from COSMIC, a facility sponsored by NASA to make computer programs available to the public. For information on program price, size, and availability, circle the reference number on the TSP Request Card in this issue.

Electronic Components and Circuits

Program Assists Design of Cabling

A common data base helps to harmonize parts of designs produced by different workers.

DFACS is an interactive, multiuser, computer-aided-engineering software tool for system-level electrical-integration and cabling engineering. The purpose of the program is to provide the engineering community with a centralized data base for entering and gaining access to definitions of the functions of systems, details of pin connections to circuits at the subsystem and instrument ends, and data on harnessing of cables. The primary objective is to provide an instantaneous single point of interchange of information, thus avoiding error-prone, time-consuming, and costly multiple-path shuttling of data.

The DFACS program, which is centered around a single data base, has built-in menus that provide easy input of and access to data for all involved system, subsystem, and cabling personnel. The DFACS program allows parallel design of sheets of data on circuits and drawings of harnesses. It also recombines raw information to generate automatically various project documents and drawings, including the index of circuit-data sheets, the list of electrical interface circuits, lists of assemblies and equipment, the electrical-ground tree, the list of connectors, the cable tree, drawings of the cabling electrical interfaces and harnesses, circuit-data sheets, and the list of interfaces and assemblies affected by engineering change requests. Real-time automatic production of harness drawings and circuit-data sheets from the same reservoir of data ensures instant har-

mony of system and cabling engineering designs. DFACS also contains automatic wire-routing procedures and extensive error-checking routines designed to minimize the probability of engineering errors.

DFACS is designed to run on DEC VAX-series computers under VMS using Version 6.3/01 of INGRES QUEL/OSL, a relational-data-base software system that is available through Relational Technology, Inc. The program is available on one 5.25-in. (13.34-cm), 360K IBM MS-DOS-format diskette. DFACS was developed in 1987 and last updated in 1990.

DFACS is a copyrighted work with all copyright vested in NASA. DEC, VAX, and VMS are trademarks of Digital Equipment Corp. INGRES QUEL/OSL is a trademark of Relational Technology, Inc.

This work was done by Joseph W. Billitti of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, Circle 11 on the TSP Request Card.*
NPO-18408

Electronic Systems

Estimating Effects of Rain on Ground/ Satellite Communication

The LeRC-SLAM program provides statistical analyses of the effects of attenuation by rain.

The frequency and intensity of the attenuation by rain that affects the communication between a satellite and an Earth terminal is an important consideration in planning a satellite link. The NASA Lewis Research Center Satellite Link Attenuation Model Program (LeRC-SLAM) provides a static and dynamic statistical assessment of the impact of attenuation by rain on a communication link established between an Earth terminal and a geosynchronous satellite. The program is designed for use in the specification, design, and assessment of a satellite link for any terminal location in the continental United States.

The basis for LeRC-SLAM is the ACTS Rain Attenuation Prediction Model, which uses a log-normal cumulative probability distribution to describe the random process of attenuation by rain on satellite links. The derivation of the statistics for the rain-rate process at the specified terminal location relies on long-term rainfall records compiled by the U.S. Weather Service during periods of up to 55 years long. The theory of extreme-value statistics is also utilized.

The user provides (1) the longitude position of the satellite in geosynchronous orbit, (2) the latitude and longitude of the Earth terminal, (3) the height of the Earth-terminal site, above sea level, (4) the yearly average rainfall at the terminal site, and (5) the operating frequency of the communication link (within 1 to 1,000 GHz, inclusive). On the basis of the yearly average rainfall at the terminal location, LeRC-SLAM calculates the relevant rain statistics for the site, using an internal data base.

The program then generates attenuation-by-rain data for the satellite link. These data include a description of the static (i.e., yearly) attenuation process, an evaluation of the cumulative probability distribution for attenuation effects, and an evaluation of the probability of fades below selected depths. In addition, LeRC-SLAM calculates the elevation and azimuth angles of the terminal antenna required to establish a link with the satellite, the statistical parameters that characterize the rain-rate process at the terminal site, the length of the propagation path within the potential rain region, and the length of its projection onto the local horizontal.

The IBM PC version of LeRC-SLAM (LEW-14979) is written in Microsoft QuickBASIC for an IBM PC-compatible computer with a monitor and printer capable of supporting an 80-column format. The IBM PC version is available on a 5.25-in. (13.34-cm) MS-DOS-format diskette. The program requires about 30K of random-access mem-

ory. The source code and executable code are included. The Macintosh version of LeRC-SLAM (LEW-14977) is written in Microsoft Basic, Binary (b) v2.00 for Macintosh II-series computers running MacOS. This version requires 400K of random-access memory and is available on a 3.5-in. (8.89-cm), 800K Macintosh-format diskette, which includes source code only. The Macintosh version was developed in 1987, and the IBM PC version was developed in 1989.

IBM PC is a trademark of International Business Machines Corp. MS-DOS is a registered trademark of Microsoft Corp. Macintosh is a registered trademark of Apple Computer, Inc.

This program was written by R. M. Manning of **Lewis Research Center**. *For further information, Circle 72 on the TSP Request Card.*
LEW-14977

Mathematics and Information Sciences

Panel Library and Editor

This program assists in the generation of software for graphical user interfaces.

The Panel Library and Editor computer program is a graphical-user-interface (GUI) builder program for use on workstations of the Silicon Graphics IRIS family. The program creates "widgets" that can be manipulated by the user. Its appearance is similar to that of the X-Windows System.

The Panel Library component of the program is written in C and is meant to be used by programmers to write user-friendly mouse-driven application programs for IRIS workstations. GUI's built by use of the Panel Library consist of "actuators" and "panels." Actuators are buttons, dials, sliders, and other mouse-driven symbols. Panels are groups of actuators that occupy separate windows on the IRIS workstation. The user of an application program can alter variables in the graphics program, or initiate the execution of functions with a click on a button. The evolution of data values can be tracked with meters and strip charts, and dialog boxes with text processing can be built. Panels can be stored as icons when not in use.

The Panel Editor component of the program is used to create and test Panel Library interfaces interactively in a simple and efficient way. The Panel Editor itself uses a Panel Library interface, so all actions are mouse-driven. Extensive context-sensitive online help is provided. A programmer can graphically create and test the user interface without writing a single line of code. Once an interface is judged satisfactory, the Panel Editor will dump it out as a file of C code that can be used in an application program.

The Panel Library (v9.8) and Editor (v1.1) are written in C language (63 percent) and Scheme, a dialect of LISP, (37 percent) for Silicon Graphics 4D-series workstations running IRIX 3.2 or higher. Approximately 10 Mb of disk space will be required once the program is compiled; 1.5Mb of main memory wil be required to execute the Panel Editor. This program is available on a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge in UNIX tar format for an IRIS workstation and includes a copy of XScheme, the public-domain Scheme-interpreter program used by the Panel Editor. The Panel Library Programmer's Manual is included on the distribution medium. The Panel Library and Editor were released to COSMIC in 1991.

Silicon Graphics, IRIS, and IRIX are trademarks of Silicon Graphics, Inc. X-Window System is a trademark of Massachusetts Institute of Technology.

This program was written by Eric Raible and David Tristram of **Ames Research Center** *and Pam Walatka of Computer Sciences Corp. For further information, Circle 74 on the TSP Request Card.*
ARC-12981

High-Resolution Rotary-to-Linear Motion Converter

A coiled shim carries a high load.

Goddard Space Flight Center, Greenbelt, Maryland

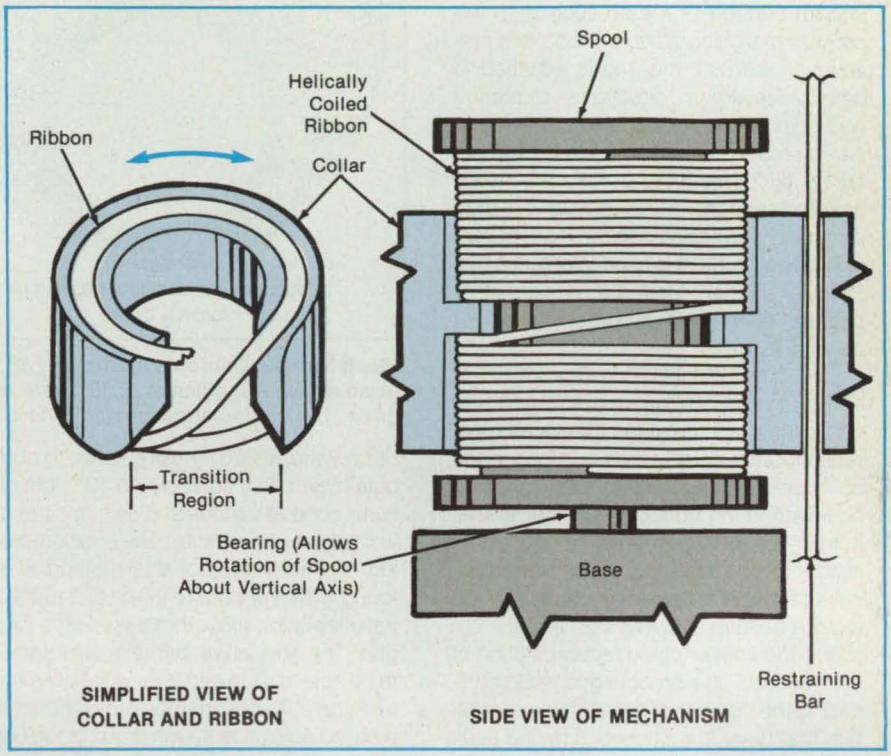
A compact rotary-to-linear motion converter combines high load-carrying ability with finely resolvable movement. The converter is simple and inexpensive to manufacture.

The device includes a collar that rides in a helical coil of a metal ribbon mounted on a spool (see figure). The ribbon passes through an opening in the collar: this opening constitutes a transition region in which the pitch of the ribbon is greater than in the parts of the coil above and below the collar. If the spool that contains the coil is rotated on a platform while the collar is restrained from rotating (but not from translating), the coil advances through the collar, one thickness of ribbon for each revolution. The rotation of the coil is thus converted into translation of the coil. Clockwise (as viewed from the top) rotation of the spool moves the collar upward, and counterclockwise rotation moves it downward.

This arrangement enables precise control of the vertical movement of the collar. For example, if the ribbon is 0.020 in. (0.508 mm) thick, the collar rises or sinks by precisely that distance with every turn of the coil. Moreover, the coil under the collar is always in compression and can thus support a large load on the collar — a load much greater than a lead-screw rotary-to-linear converter of equal resolution could support, for example.

The fine pitch of the device helps to prevent vibrations from inadvertently backdriving the collar. Thus, locking mechanisms like those on ball-screw converters are unnecessary.

The coil can be made from flattened roll-formed wire. This material is inexpensive, strong, and resistant to fatigue.



A **Helical Coil of Metal Ribbon** is wrapped around a spool. A bearing supports the spool on a fixed base. The restraining bar prevents the collar from rotating, but allows it to rise and fall. A 1,000-turn coil of ribbon 0.010 in. (0.254 mm) thick would provide for translation of the collar over a distance of 10 inches (25.4 centimeters).

This work was done by M. Bruce Millam and Philip Studer of **Goddard Space Flight Center**. *For further information, Circle 85 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center [see page 30]. Refer to GSC-13141.

Adaptive Grids for 3-D Parabolized Navier–Stokes Computations

Computational grids are adjusted iteratively to reduce errors.

Ames Research Center, Moffett Field, California

A procedure for the iterative adjustment of computational grids has been developed for use in numerical solution of the three-dimensional parabolized Navier–Stokes equations of flow. The essence of the procedure is to refine (or coarsen) the grid in regions of high (or low, respectively) gradients in the initial computed flow so that on subsequent iterations, one can satisfy the competing requirements to (1) produce a solution that captures such pertinent features as shock waves and boundary layers, the accurate resolution of which typically requires fine meshes; and (2) prevent unnecessary refinement of the mesh elsewhere, thereby preventing an undue increase in the amount of computation.

The procedure is one implementation of the solution-adaptive-grid method, which was described in "Adaptive Grids for Computations of Three-Dimensional Flows" (ARC-12479), *NASA Tech Briefs*, Vol. 15, No. 8 (August, 1991), page 66. To recapitulate: The grid points are considered to be connected by fictitious tension and torsion springs, and the configuration of the grid is found by use of a variational principle that minimizes the potential energy stored in the springs. The stiffnesses of the springs are adjusted for the next iteration in response to flow-field quantities computed during the present iteration.

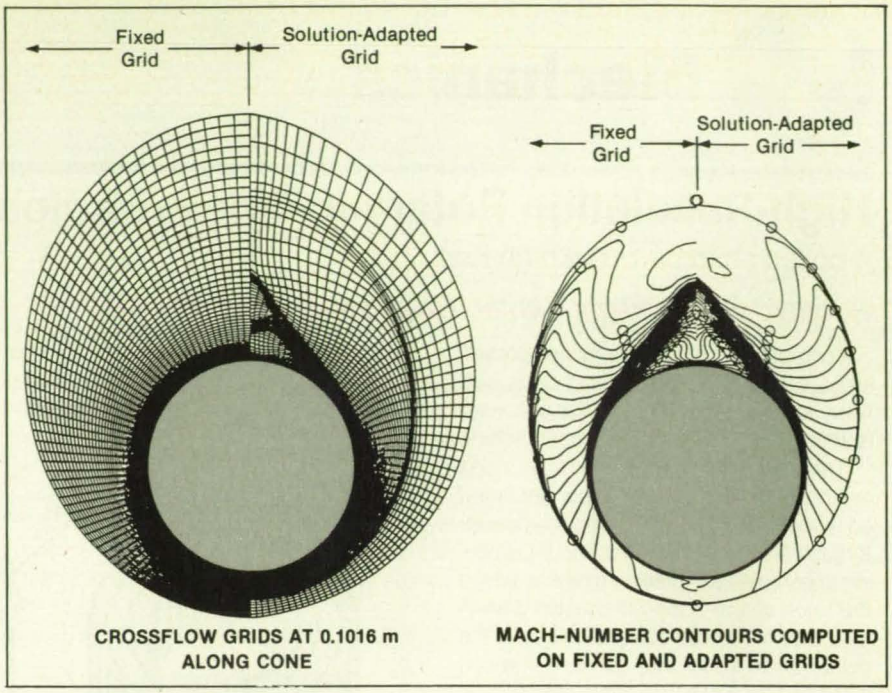
The forces in the tension springs are functions of the local errors in the computed flow field, which errors are related to gradients of selected dependent flow

variables and/or curvatures of stream lines and flow surfaces. The torsional springs help to limit the skewness (the local departure from orthogonality) of the grid.

The parabolized Navier–Stokes equations are approximations of the steady-state Navier–Stokes equations and are solved by a space-marching numerical-integration method. The first step in performing the numerical integration in conjunction with the solution-adaptive-grid procedure is to obtain an initial solution on the cross-stream surface that corresponds to the present marching station. Using this preliminary solution, the grid is adjusted in both cross-stream directions, clustering grid points in regions of high gradients or curvatures. A refined solution is then obtained by remarching across the newly adapted surface. The adapted grid is then projected downstream to the next marching station, where it is used to obtain a preliminary solution. Then the process is repeated, each time progressing farther downstream.

One of the distinguishing characteristics of the present solution-adaptive-grid procedure is that it provides for the efficient redistribution of grid points along each computational coordinate line, using an equidistribution concept. Another is that it limits the displacements of grid points in adaptations so as to prevent the numerical instability that could be caused by too rapid a buildup of skewness, thereby enabling the uninterrupted recomputation of the flow field on a smooth grid while minimizing the number of adaptation parameters that have to be supplied by the user.

The solution-adaptive-grid procedure and associated numerical-integration algorithm were tested by using them to compute hypersonic flows over a 10° right circular cone at various angles of incidence in its plane of symmetry. The shock-resolving characteristics of this method were found to be superior to those of a numerical-integration algorithm based on a fixed grid. The adaptation process was shown to be able to align grid lines with flow structures (see figure), thereby providing for increased resolution in high-gradient regions.



CROSSFLOW GRIDS AT 0.1016 m ALONG CONE

MACH-NUMBER CONTOURS COMPUTED ON FIXED AND ADAPTED GRIDS

Mach-Number Contours in a mach 7.95 free-stream flow about a 10° right circular cone at an angle of incidence of 16° were computed by use of fixed and solution-adapted grids. The circles show positions of shock waves.

This work was done by A. D. Harvey and S. Acharya of Louisiana State University and S. L. Lawrence of **Ames Research Center**. *Further information may be found in AIAA paper A91-19137, "A Solution-Adaptive Grid Procedure for the Three-Dimensional Parabolized Navier–Stokes Equations."*

Copies may be purchased [prepayment required] from AIAA Technical Information Service Library, 555 West 57th Street, New York, New York 10019, Telephone No. (212) 247-6500.

ARC-13073

High-Precision Coupling Mechanism Operable by Robots

Features include kinematic mounts and protection against overtightening.

Goddard Space Flight Center, Greenbelt, Maryland

A coupling mechanism has features that make it both easily operable by hand and suitable for operation by robots: it tolerates some initial misalignment, imposes precise final alignment, and protects itself against overtightening. The coupling mechanism would typically be used to mount an equipment module (e.g., a scientific instrument or a package of electronic circuitry) on a structure.

The coupling mechanism consists of two assemblies: the baseplate assembly (which would typically be attached to the structure) and the replaceable-plate assembly (which would typically be attached to the equipment module). Figure 1 illustrates the components of the two assemblies and the spatial relationships between them. Although this figure is mostly self-explanatory, it is important to point out that the three pairs of mating components connected by dashed lines — the left conical post and slotted bar, the two flat-topped posts, and the right conical post and cup — constitute a set of standard kinematic mounts, which enforce alignment.

At the beginning of a coupling sequence, the two assemblies are brought close to each other, and the mating kinematic mounts are aligned approximately. The holddown bolt on the baseplate assembly is made to engage the floating nut on the replaceable-plate assembly. As the bolt is tightened, the right conical post settles into the mating conical hole in the cup, the left conical post settles into the mating V-cross-section slot, and the two flat-topped posts make contact.

As shown schematically in Figure 2, the holddown bolt and the floating nut do not apply clamping force in the middle of the assembly: application of clamping force in the middle could bend the nominally rigid plates to which the structure and the equipment module are attached. Instead, the holddown bolt and floating nut apply the clamping force via flexible (that is, springy) plates to standoff posts directly in line with the kinematic mounts. Once the kinematic mounts make contact, the bolt and nut are tightened further, deflecting the flexible plates and building up a spring preload that keeps the two assemblies clamped together. The stop collar on the holddown bolt provides a very repeatable amount of preload to the flexible plates. Any attempt to tighten the bolt and nut beyond the limit merely presses the stop collar and nut against opposite sides of the lower flexible plate, and does not increase the clamping force. The repeatability of the interface was tested and found to be better than forty-millionths

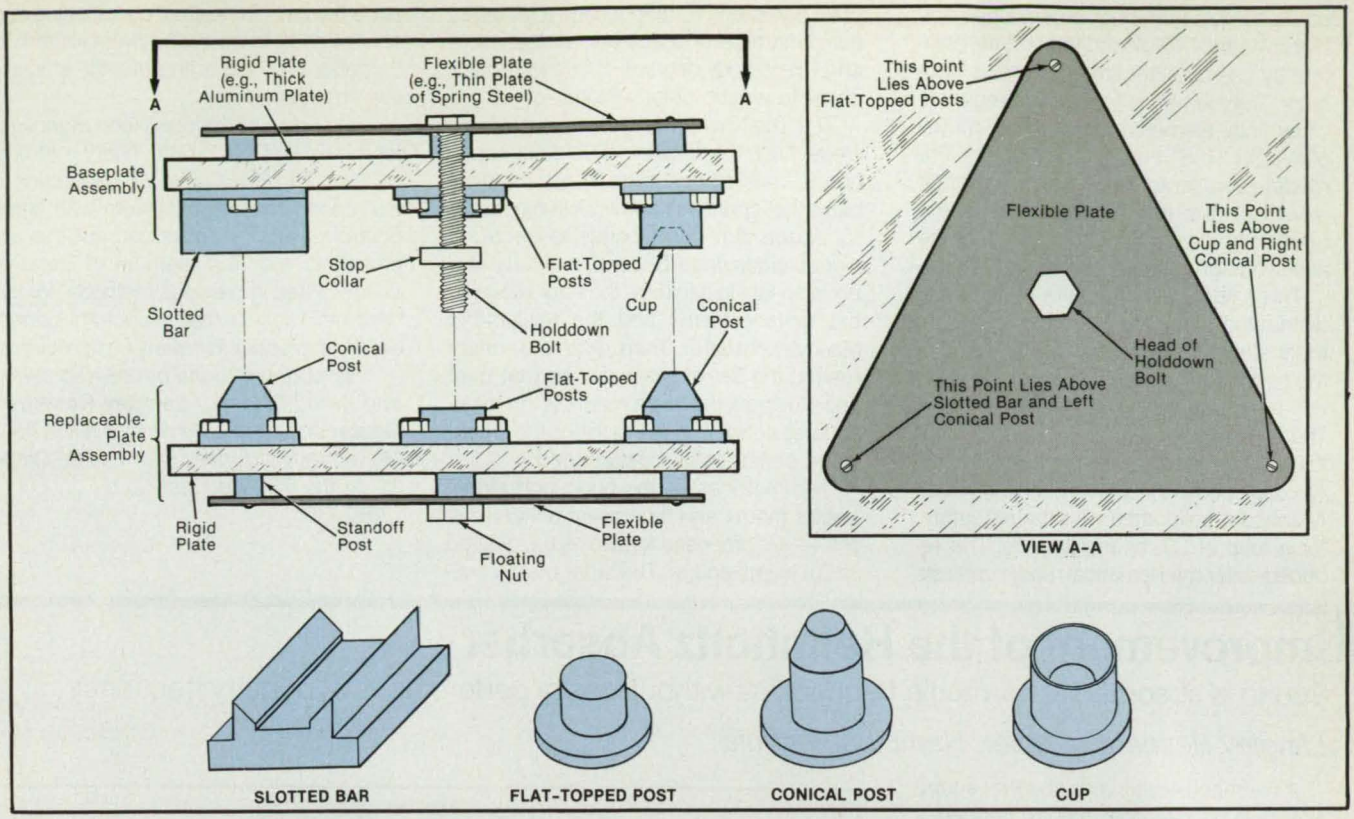


Figure 1. The **Coupling Mechanism** includes kinematic mounts, which tolerate small initial misalignment and enforce precise final alignment as the two assemblies are brought together.

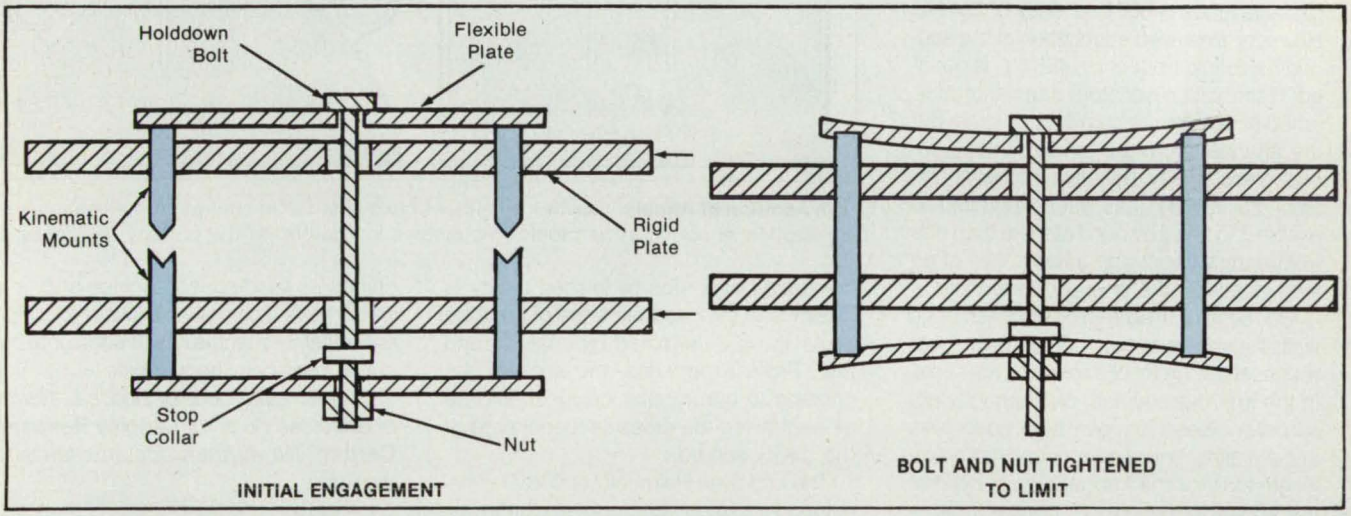


Figure 2. The **Clamping Force** is applied to the kinematic mounts via two flexible plates. The bolt and nut are tightened on the flexible plates to impose a spring clamping load.

of an inch.

This work was done by George Voellmer of **Goddard Space Flight Center**. *For further information, Circle 82 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center [see page 30]. Refer to GSC-13360.

Robust Assignment of Eigensystems for Flexible Structures

The open-loop eigenvector matrix and its closest unitary matrix are selected.

Langley Research Center, Hampton, Virginia

The assignment of an eigensystem for a multiple-input, multiple-output system by use of linear, constant-state, or output feedback plays an important role in shaping the transient response of the system. Recent research has been directed toward the development of reliable algorithms for the design of controllers that are robust and that satisfy constraints on the placement of eigenvalues. In this case, "robustness" denotes the insensitivity of the closed-loop eigenvalues to uncertainties and perturbations in the system.

Accordingly, one of the results of recent development efforts is an improved meth-

od for the placement of eigenvalues and eigenvectors of a closed-loop control system by use of either state or output feedback. The method is applied to a reduced-order finite-element mathematical model of NASA's MAST truss beam structure. The model represents the deployer/retractor assembly, the inertial properties of the Space Shuttle, and rigid platforms for the allocation of sensors and actuators.

Three secondary actuator stations are distributed along the beam, and one primary station is located at the tip. Each of the secondary actuator stations contains two actuators acting in the same plane. The primary station contains four actuators to impart torques as well as in-plane forces. Also included are displacement and velocity sensors collocated with the actuators, for a total of 20 measurements. The reduced-order mathematical model consists of 92 first-order equations, and it includes the dynamics of actuators and sensors and 6 rigid-body degrees of freedom in addition to elastic deformations.

The method basically involves three steps. First, the singular-value decomposition is used to generate an orthonormal basis that spans the admissible eigenvector space that corresponds to each assigned eigenvalue. Second, a unitary matrix is sought to minimize the error between the unitary matrix and the assignable eigenvector matrix. Third, given the unitary matrix, the set of eigenvectors that best approximates the given matrix in the least-squares sense and still satisfies the eigenvalue constraints is determined.

Two matrices — the open-loop eigenvector matrix and its closest unitary matrix — are proposed for use as the desired set of eigenvectors. The latter matrix generally favors both minimal conditioning and control gain. In addition, the algorithm is formulated in real arithmetic for efficient implementation.

The choice of the open-loop eigenvector matrix and its closest unitary matrix is believed to be suitable for generating a well-conditioned eigensystem with small control gains. The implication of this approach is that the element of iterative search, used in previous methods, for the "optimal" unitary matrix appears unnecessary in practice for many test problems.

This work was done by Jer-Nan Juang and Kyong B. Lim of **Langley Research Center** *and John L. Junkins of Texas A&M University. For further information, Circle 31 on the TSP Request Card.*
LAR-14305

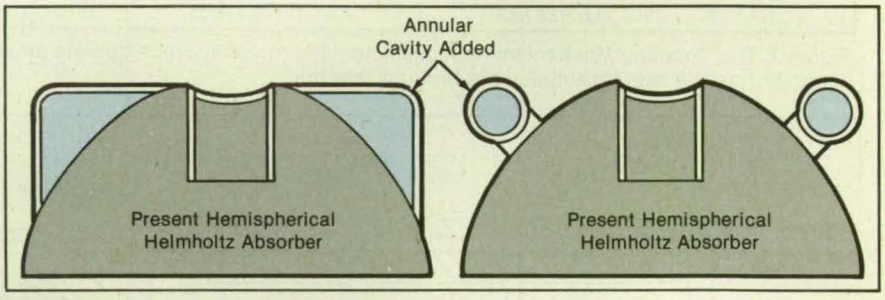
Improvement of the Helmholtz Absorber

Sound is absorbed at harmonic frequencies without loss of performance at primary frequency.

Langley Research Center, Hampton, Virginia

A Helmholtz resonator absorbs sound energy in only a single, narrow frequency band. In one NASA program, a system of absorbers is designed for a propeller-blade-passage fundamental frequency of 234 Hz. However, improved attenuation at the second-harmonic frequency, 468 Hz, is needed. Helmholtz resonators can be scatter-tuned to perform at both frequencies, but the attenuation at the fundamental is reduced accordingly. Therefore, the Helmholtz-resonator system has been improved to enable it to absorb sound at more than one frequency without appreciable loss of effectiveness at the primary frequency.

Because of the inherent stiffness of its wall, the sphere or hemisphere is the best shape for the Helmholtz absorber elements. In the improved system of Helmholtz absorbers, closed or open tube absorbers that are either one-quarter or one-half wavelength long for the frequencies of interest are added to the spaces between hemispheres (see figure). The center from which the radius of a tube or formed cavity is drawn, and the circumference of the tube or cavity, is determined by analysis and test. From experience, the area of the opening to the annular cavity should be at least twice the cross-sectional area of the cavity served.



The **Addition of Annular Cavities** (in either of two alternative configurations) enables the absorption of sound at harmonic frequencies in addition to the primary frequency.

The improved Helmholtz absorber is designed for use on structures of high transmission loss. It can be applied to such machines as fixed-speed engines and fans, which have high noise output at fixed fundamental frequencies, with additional output at harmonic frequencies.

This work was done by Duane L. Morrow of Lockheed Corp. for **Langley Research Center**. *No further documentation is available.*
LAR-14222

Screw-Thread Inserts as Temporary Flow Restrictors

Friction alone (without tapped threads) holds the inserts against moderate upstream pressures.

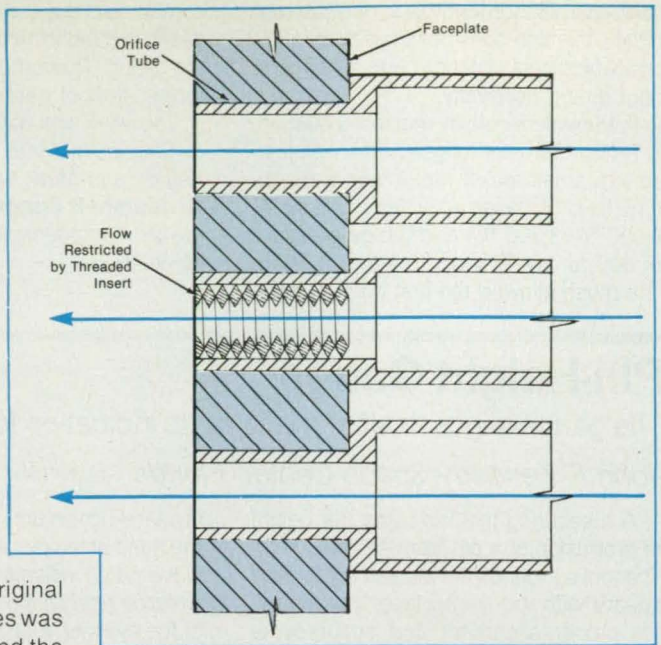
Lewis Research Center, Cleveland, Ohio

Coil-spring screw-thread inserts have been found to be useful as temporary flow restrictors. The inserts (available commercially under the trade name "Heli-Coil") are placed in the holes through which flow is to be restricted, effectively reducing the cross sections available for flow.

Unlike in most other applications of screw-thread inserts, the holes are not tapped to match the insert threads; however, the inserts are otherwise installed in the usual way by screwing them in, which coils them up more tightly to fit in the hole, then releasing them to spring outward against the inside walls of the holes. Thereafter, they are held in place against upstream pressure by friction induced by the spring forces against the walls. Later, they can be removed and placed in other holes as needed.

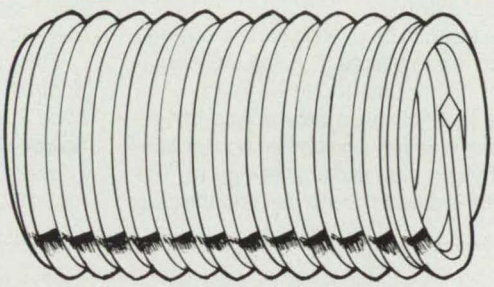
The use of coil-spring thread inserts as flow restrictors was conceived as an inexpensive solution to the problem of adjusting the flow of oxygen through orifices in a faceplate (see figure) into a hydrogen/oxygen combustion chamber. The orifices are thin-wall tubes that protrude through holes in the faceplate. The installation and removal of the threaded inserts proved to be gentle enough not to deform the orifice tubes. An attempt to restrict the flow by a more-conventional method such as driving or threading plugs into the orifices would have deformed the tubes and could have caused the faceplate to seize in place.

Coil-Spring Screw-Thread Inserts were placed in some of the tubes to restrict the flows through them. The insides of the tubes were not threaded; the inserts were held in place by friction alone.



In this case, the original diameter of the orifices was 0.093 in. (2.4mm), and the inserts were of size #1-64. These inserts were found to withstand an upstream pressure of 70 psig (480 kPa) without blowing out.

This work was done by Paul Trimarchi of **Lewis Research Center**. *For further information, Circle 65 on the TSP Request Card.*
LEW-15293



DETAIL OF THREADED INSERT

Thermal Barrier for Vented O-Ring Seal

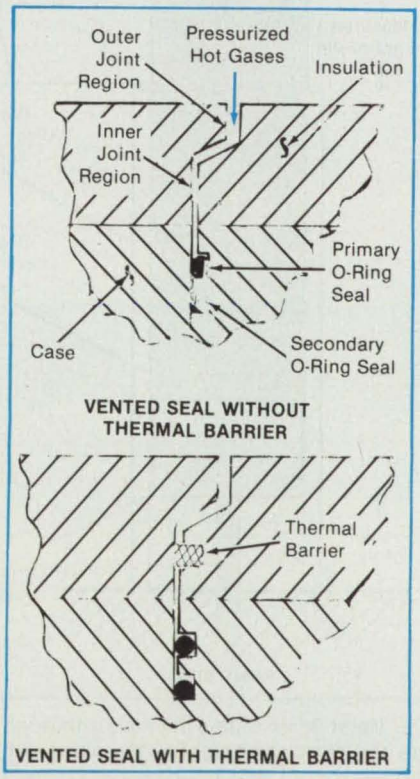
The barrier allows gases to seat the seal without damaging it.

Marshall Space Flight Center, Alabama

A porous barrier of tungsten-wire mesh cools and admits initially-hot pressurized gases to a seal gland so that they can push an O-ring into its seat and thereby help to ensure the integrity of the seal (see figure). At the same time, the barrier cools the gases and distributes them more nearly uniformly so that they do not erode the O-ring material. The barrier was devised for use in a rocket motor. Potential terrestrial applications may include aircraft engines, furnaces, and ducts that carry hot gases.

The knitted tungsten-wire mesh resists attack by the hot, high-pressure gases. It has a high specific heat and thus can absorb substantial heat from the gases and cool them to a safe temperature. The mesh is highly compressible, yet does not have a high specific surface area. In addition,

The **Ring of Tungsten-Wire Mesh** forms a protective barrier between hot, pressurized combustion gases and O-rings. The mesh cools and depressurizes the gases so that they can safely push on and thereby help to seat the primary O-ring (or the secondary O-ring if the primary O-ring fails to form a seal).



unlike porous barriers made of other materials, this one does not shed fibrous debris (which could interfere with seating the ring) during assembly.

A 15-percent-density mesh of 0.0045-in. (0.11-mm)-diameter tungsten wire was tested in a small rocket motor with a mach-0.15 flow of gases at a temperature of 6,000 °F (3,300 °C) and gauge pressure of 800 to 1,000 lb/in.^{2} (5.5 to 6.9 MPa). The mesh allowed the first burst of pressure to seat the O-ring, while cooling the gases and reducing the rate of flow toward the O-ring. Thereafter, the mesh hindered further flow of gases to the O-ring.

This work was done by H. Schick, Philip S. Shadlesky, Mark C. Perry, Donald M. Ketner, and Mark Salita of Thiokol Corp. for **Marshall Space Flight Center**. *No further documentation is available.*
MFS-28628

Pin-Height Gauge

The gauge aligns itself and retains its indication for later reading.

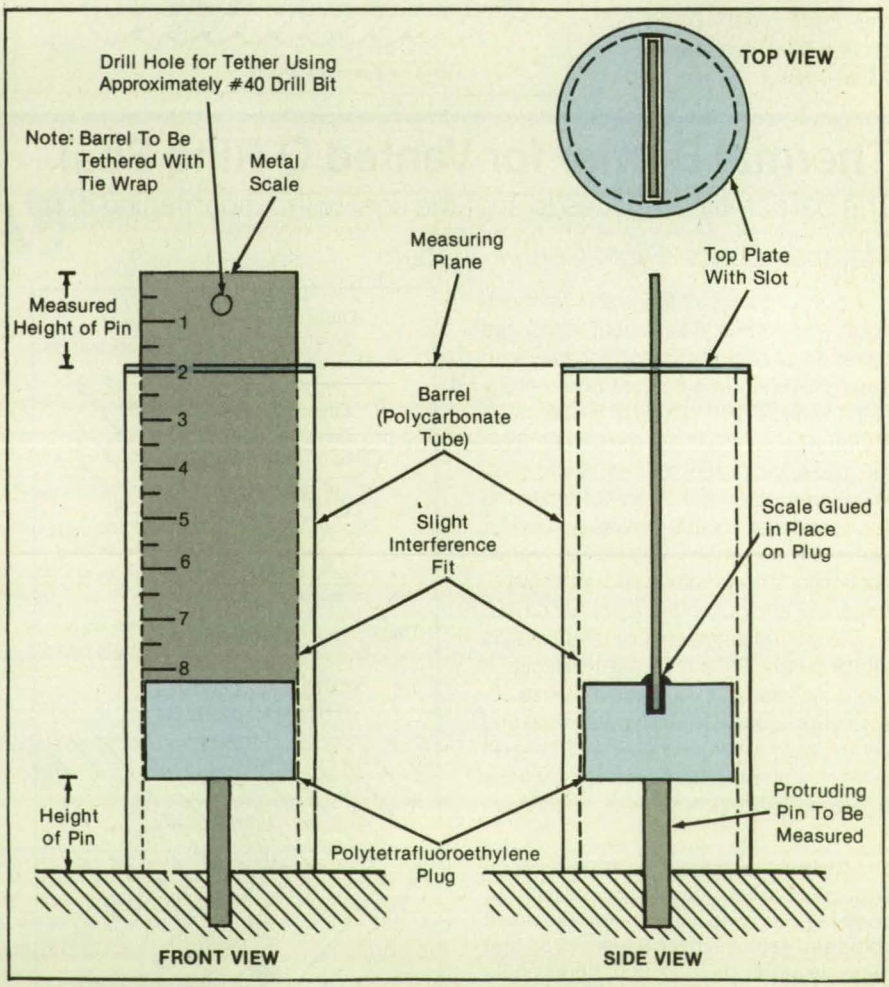
John F. Kennedy Space Center, Florida

A measuring tool indicates the height of protrusion of a pin from a flat surface. The tool surrounds the pin and holds itself square with the flat surface, thus ensuring proper alignment and accuracy of measurement.

The tool can be used in hard-to-see and hard-to-reach places. It holds the indication of height until it can be read.

The tool includes a clear polycarbonate cylinder in which a pistonlike polytetrafluoroethylene plug slides (see figure). The cylinder is placed over a pin, and the plug is pushed down until it makes contact with the head of the pin. A metal scale bonded to the piston indicates the height of the pin, which is read as the scale value at the top of the cylinder. A slight interference fit between piston and cylinder ensures that the scale stays in place until deliberately moved.

This work was done by Daniel R. Sumrall and Vincent P. Nichols of Lockheed Space Operations Co. for **Kennedy Space Center**. *No further documentation is available.*
KSC-11524



The **Metal Scale Slides** in and out through the slot in the top plate. The scale value at the slot gives the height of the pin under the piston. Dimensions are in inches.

Study of Spacecraft Capsule Reentering the Atmosphere

Heating, decelerations, and related issues are discussed.

A report describes a computational study of the heating and deceleration of the crew capsule of a spacecraft entering the atmosphere of the Earth upon return from Mars. Issues pertaining to heating and deceleration are considered in the context of related issues pertaining to navigation, maneuverability of the spacecraft, and safety.

It is assumed that the capsule would make a single-pass, direct entry followed by a parachute landing from a hyperbolic-orbit (escape-trajectory) speed of as much as 16 km/s. Emphasis is placed on a nominal speed of 14 km/s, and lesser emphasis on speeds in the range from 12 to 16 km/s. To prevent injury to the crew, the maximum allowable deceleration would be 5 times normal gravitational acceleration, g, at the surface of the Earth.

A single pass (rather than multiple passes) through the atmosphere is chosen because previous studies have shown that less precision is required to guide the spacecraft through the single-pass maneuvers and the total heat input is less than in multiple passes. Various capsule configurations (as opposed to a winged configuration like that of the Space Shuttle) were studied because they have smaller windward surfaces and, consequently, less mass would have to be devoted to heat shielding.

The flow fields about the capsule are computed by use of a Navier–Stokes computer code. Laminar and turbulent convective heating, chemical effects, and thermal radiation are taken into account. Trajectories are computed for flight conditions near and at the undershoot and overshoot boundaries. Capsule shapes that yield various of lift-to-drag ratios (L/D) are considered.

For entry at 14 km/s, it is found that L/D of 0.5 is required to provide an allowable range of about 0.9° in the angle of entry at a nominal altitude of 122 km for the specified deceleration limit of 5 g. The L/D of 0.3 of the Apollo spacecraft is found to be inadequate. The peak rates of heating at the stagnation point are found to range from about 0.87 kW/cm^2 for the overshoot trajectory to 1.33 kW/cm^2 at undershoot, for a ballistic coefficient of 300 kg/m^2. For a blunted, raked cone with L/D = 0.5, the peak heating rate near the aft end of the forebody is found to vary from 0.14 to 0.23 kW/cm^2 in laminar flow, but if ablation triggers boundary-layer transition, the peak heating can rise to 0.5 or up to 0.72 kW/cm^2.

All rates of heating are sufficiently high to make ablative heat shields necessary. The total heat load at the stagnation point is about 100 kJ/cm^2. The total heat load near the aft end of the forebody is about 20 kJ/cm^2 for a laminar boundary layer, and approaches 90 kJ/cm^2 if fully turbulent flow is assumed to occur during the entire entry.

This work was done by Michael Tauber and Grant Palmer of **Ames Research Center** *and Lily Yang of Sterling Software. Further information may be found in AIAA paper 90A-38402, "Earth Atmospheric Entry Studies for Manned Mars Mission."*

Copies may be purchased [prepayment required] from AIAA Technical Information Service Library, 555 West 57th Street, New York, New York 10019, Telephone No. (212) 247-6500.

ARC-12826

Lateral Deflections of Ball Bearings Reveal Wear

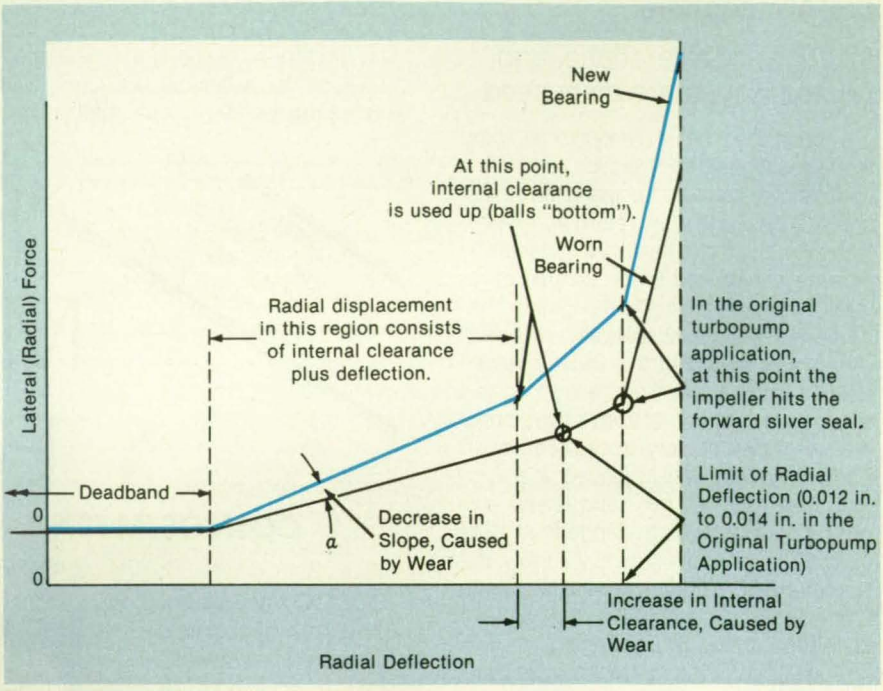
Wear can be quantified in terms of equivalent spring stiffness.

Marshall Space Flight Center, Alabama

The wear in ball bearings that support a shaft in a housing can be quantified via measurement of the lateral (radial) deflection of the shaft with respect to the housing as a function of the lateral force applied between the shaft and the housing. This method was devised to estimate wear in the bearings of the high-pressure-liquid-oxygen turbopump of the main engine of the Space Shuttle, without having to disassemble the pump or dismount it from the engine. The method is probably applicable to other rotating machinery and may help inspectors to determine quickly, noninvasively, and in the field whether bearings should be replaced.

The method is related to the familiar informal and qualitative "jiggle test" of bicycle and automotive ball bearings. In this more formal and quantitative method, one plots the lateral (radial) force versus deflection to obtain a plot that shows internal radial clearance, radial stiffnesses, and points of change of radial stiffnesses (see figure). The plot serves as the basis of a calibration profile that can be correlated directly or indirectly with ball-bearing wear.

A baseline plot is obtained by performing the measurements on the machine equipped with new bearings. This plot defines one of the principal points of increase of radial stiffness; namely, the point at which the internal clearance is used up. The radial-deflection coordinate of this point increases with wear. By comparing this coordinate to that of a new bearing, one can obtain a direct measure of wear.



The **Force Necessary to Produce a Given Lateral Deflection** is measured over a range large enough to characterize radial clearances and stiffness.

One can also quantify wear in terms of the change in the radial stiffness, as indicated by the change in the slope of part of the force-versus-displacement plot. Data from a mathematical model of the static radial stiffnesses of bearings indicate that bearings behave as softer radial springs as they wear.

This work was done by Gaston A. Gurada and David L. Wineland of Rockwell International Corp. for **Marshall Space Flight Center**. *No further documentation is available.*
MFS-29813

Pneumatic Pellet-Transporting System

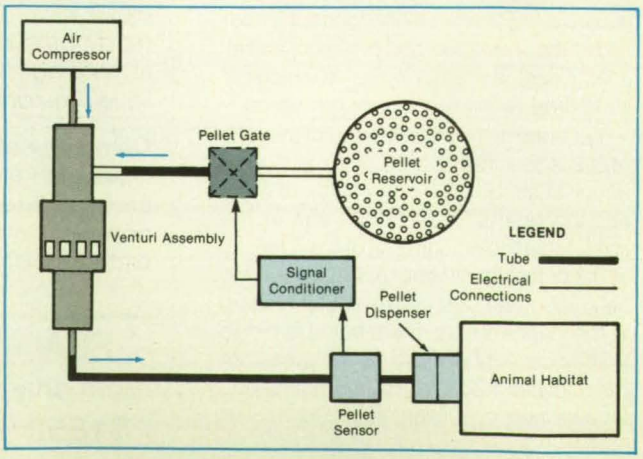
The flow of air through a venturi assembly would entrain pellets.

Ames Research Center, Moffett Field, California

A proposed pneumatic system would transport food pellets to confined animals. The flow of air into a venturi assembly would entrain round pellets, drawing them from a reservoir into the venturi for transport by airflow.

The system (see figure) would include a bulk pellet reservoir with a gate at its outlet, a venturi assembly with a pellet-retainer/bleed-air tube, transport tubes, an in-line pellet sensor, and a pellet dispenser to hold the transported pellets.

An experimental partial prototype included only the venturi assembly, a simple pellet reservoir, and transport tubes.



The **Pneumatic Pellet-Transporting System** would include a venturi assembly, which creates a flow of air that would draw pellets into the system.

An air compressor supplied the air to operate the venturi. The venturi assembly was machined from acrylic rod 1.5 in. (38.1 mm) in diameter. The expansion chamber at the downstream end of the venturi throat flared at a 7° angle; its outlet end was about 2.5 times the diameter of the venturi throat.

The inlets and outlet of the venturi were brass tubes 7/16 in. (11.1 mm) in inside diameter. Pellet-transport tubes of 1/2-in. (12.7-mm) inside diameter were used. Eight rows of 1/16-in. (1.6-mm) diameter were drilled along the length of the 0.5-in. (12.7-mm) inside-diameter pellet-retainer/bleed-air tube. The pellet reservoir was made from a whiffle ball.

In tests, the prototype system transported 3/8-in. (9.5-mm) diameter acrylic plastic spheres through flexible plastic tubing; however, some pellet jams occurred. During the tests, pellet separators were placed in the reservoir in an attempt to eliminate pellet jams at the reservoir outlet. Although some jams continued to occur, this does not appear to be an insurmountable problem.

The number of pellets that can be successfully transported at one time depends on the design of the venturi, the configuration of the system (particularly with respect to heights in a 1-g environment), the masses and sizes of pellets, and the rates of flow of air. In the prototype system, the pressure differential was insufficient to transport more than about 20 pellets at once along the 6 ft (1.8 m) of downstream tubing, especially inasmuch as there was a 3- to 4-in. (7.5- to 10-cm) uphill section near the end of the 6-ft tube. The speed of the pellets in the tube was about 6 ft/s (1.8 m/s).

This work was done by George Wood of Lockheed Engineering and Sciences Co. and Robert A. Pugsley of General Electric Government Services for **Ames Research Center**. *For further information, Circle 103 on the TSP Request Card.*
ARC-12816

Positioning Mechanism for Hoisting

Objects are guided to the proper position for removal by lifting.

Goddard Space Flight Center, Greenbelt, Maryland

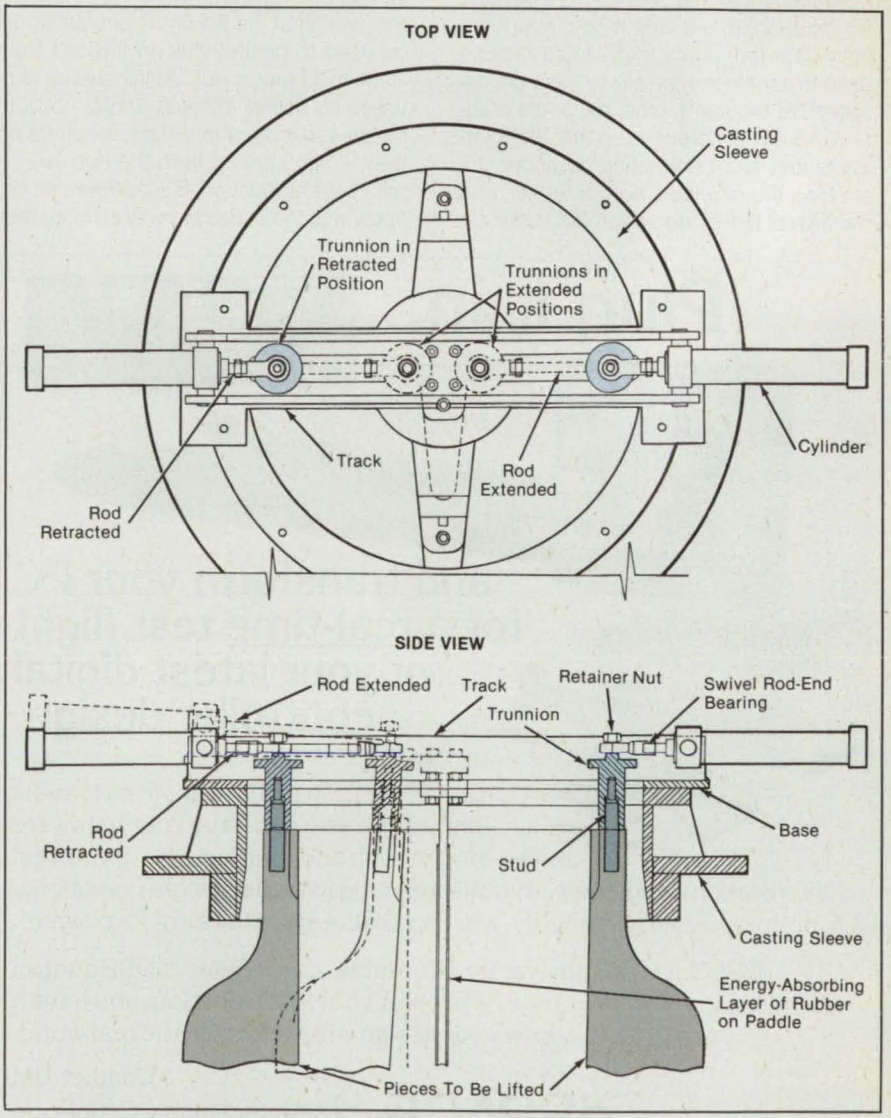
A mechanism positions large, heavy objects in a container for lifting out of the container by a hoist, crane, or winch. The mechanism handles the objects gently and ensures that they are lifted cleanly away in a vertical direction without bumping the container. It was developed for lifting offset pieces of solid-propellant core out of a rocket motor through its propellant port. Similar specialized mechanisms could be developed to lift other specially shaped, specially contained heavy objects.

The base of the mechanism is placed over the propellant port (see figure). The base includes a track for trunnions that are screwed onto studs on the tops of the pieces of core to be lifted. Each trunnion is attached to a rod in a hydraulic cylinder that extends horizontally and radially toward the center of the propellant port.

To begin to position a piece of core for lifting, a hydraulic cylinder is activated so that it extends its rod and drives its trunnion radially inward along the track. This tilts the upper end of the piece of core so that its upper end approaches the center of the bin. Next, the base is lifted, freeing the lower end of the piece of core to swing inward. The swinging piece of core strikes a rubber-covered aluminum paddle, which absorbs the kinetic energy of the swing and brings the piece of core to rest near the axis of the motor. Another piece of core on the opposite side of the motor is manipulated similarly. Then the positioning mechanism and both pieces of core can be lifted from the motor by a remotely controlled hoist.

This work was done by John D. Marlin, III, Barry J. Moore, and Robert I. Myers of Morton Thiokol, Inc., for **Goddard Space Flight Center**. *No further documentation is available.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center [see page 30]. Refer to GSC-13242.



The **Track in the Base of the Mechanism** guides each trunnion and the piece to which it is attached to the middle as hydraulic rods extend. When the mechanism is lifted, the tilted pieces swing inward and come to rest on the energy-absorbing paddle.

Smoother Conversion From Helicopter to Airplane

Rotor blades would be retracted while still rotating to reduce instability.

Ames Research Center, Moffett Field, California

A proposed high-speed rotorcraft would convert between rotating-wing flight and fixed-wing flight without high vibration. It would function both while hovering and while moving at transonic or low supersonic speeds.

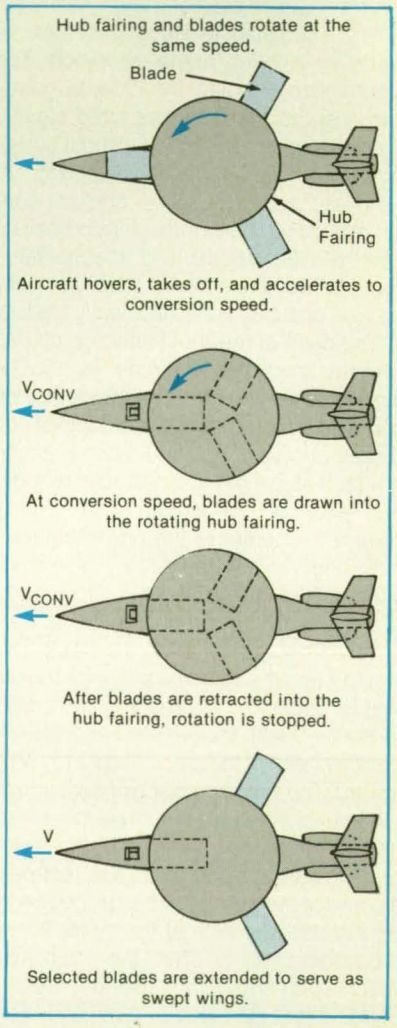
The rotor blades would extend from a disk-shaped hub fairing of about half the diameter of the rotor-tip circle. The chords of the rotor blades would be larger than those of conventional helicopter blades — more nearly like those of fixed wings. The blades could be standard asymmetrical airfoils or airfoils symmetrical about the half-chord position. The aircraft would be powered by fan-jet engines, and the rotor would be driven by fan-jet exhaust ducted to, and venting from, the tips of the blades or the edge of the fairing.

To prepare for the change from helicopter mode to an airplane mode in forward flight, the fan-jet engines would first be used to accelerate the aircraft to a critical speed. At the same time, the angle of attack would be increased so that the rotating fairing and nonrotating components, such as the fuselage, horizontal tail, and canard surfaces, would furnish sufficient lift. The blades would then be retracted into the rotating fairing. The rotation would then be halted, and the two blades would be extended to serve as wings. (In the case of a three- or four-blade rotor, the two rearmost blades would be extended to serve as swept wings.) The aircraft would then proceed in fixed-wing configuration. By retracting the blades into the hub fairing during rotation, the unfavorable offset between the aerodynamic center and the blade center of gravity is eliminated, and the blade oscillatory airloads are eliminated, thereby suppressing the instability and vibration that otherwise occurs when a rotor is stopped in an airstream.

In hovering or slow helicopter flight, the pitch of the rotor blades would be varied by electromechanical rotary actuators to control the pitch and roll of the aircraft. A reaction jet at the tail of the aircraft would be used to control yaw. In forward flight in the fixed-wing mode, pitch could be controlled by use of canards and/or horizontal tail surfaces plus the pitch control on the "wings" jutting from the hub fairing; roll could be controlled by differential deflection of the canards, differential deflection of the horizontal tail surfaces, and/or differential pitch of the "wings"; and yaw would be controlled by deflection of the rudder on the vertical tail fin.

To convert from fixed-wing mode to rotating-wing mode, the process would be reversed. First, the aircraft would slow down to conversion speed, the blades would be retracted into the faring and the fairing would be brought up to full rotational speed. The blades would then be extended, and the aircraft would slow further and maneuver to a landing site, come to a hover, and land.

This work was done by Robert H. Stroub of **Ames Research Center**. *For further information, Circle 48 on the TSP Request Card.* *ARC-11881*



The **Aircraft Would Take Off** and hover like an ordinary helicopter. After accelerating to a sufficient forward speed for conversion, the rotor blades would be retracted into the large, rotating hub fairing. Rotation would then be stopped. Two blades would be extended to serve as wings, and the aircraft would accelerate to its cruising speed.

Fixture for Drilling and Tapping a Curved Workpiece

A made-to-order template positions and orients drills and taps.

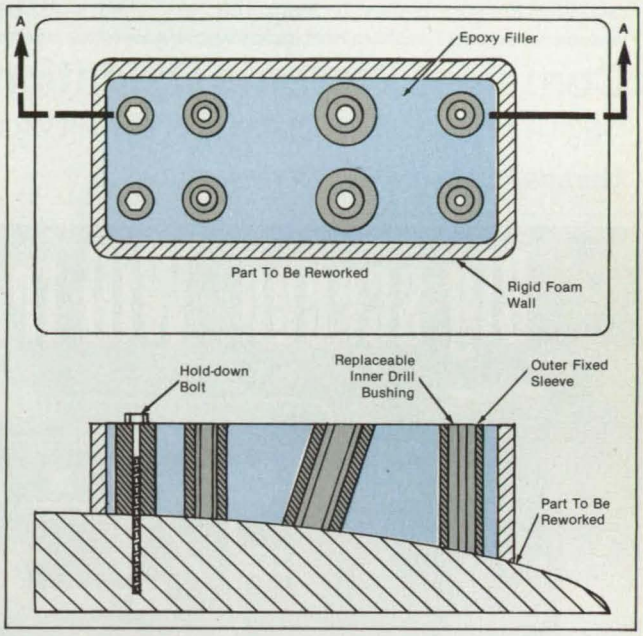
Ames Research Center, Moffett Field, California

A simple fixture guides the drilling and tapping of holes in prescribed locations and orientations on a workpiece that has a curved surface. The tool was conceived for use in reworking complexly curved helicopter blades made of composite materials.

The fixture (see figure) is a block of rigid foam with an epoxy filler, custom-fitted to the surface contour, containing bushings and sleeves at the drilling and tapping sites. The bushings can be changed, so that taps and drills of various sizes can be accommodated.

The fixture is made by the following steps:

- Cut a block of rigid urethane foam to match the surface contour at the site. Cut out the middle of the block so that only an outer wall of foam remains. The outer wall will serve as a mold to fabricate the fixture.
- Cover the surface of the workpiece with a release material. Position the fixed metal sleeves so that they are centered on the sites of the holes to be drilled and/or tapped. (Those ends of the sleeves that make contact with the workpiece have previously been cut at the angles that will give the required slants to the drills and taps relative to the surface. Circumferential grooves have also been cut in the sleeves so that they can be gripped more strongly by the epoxy matrix.) Cover the bottom of the wall with a thin layer of epoxy and place the wall around the sleeves on the workpiece.
- Fill the space around the sleeves with epoxy filler and let it harden, taking care that drops of epoxy do not fall inside the sleeves.
- Choose bushings with inside diameters to accommodate the drills and/or taps to be used and place them in the sleeves.



The Fixture for Drilling and Tapping conforms to the curved surface of the workpiece. Sleeves and bushings—perpendicular to the surface or slanted—orient the drill bits or taps.

The fixture is now ready for use. In use, the fixture is secured to the surface by hold-down bolts extending through the sleeves and into threads in the substrate.

This work was done by P. S. Espinosa and R. T. Lockyer of **Ames Research Center**. *For further information, Circle 62 on the TSP Request Card. ARC-13164*

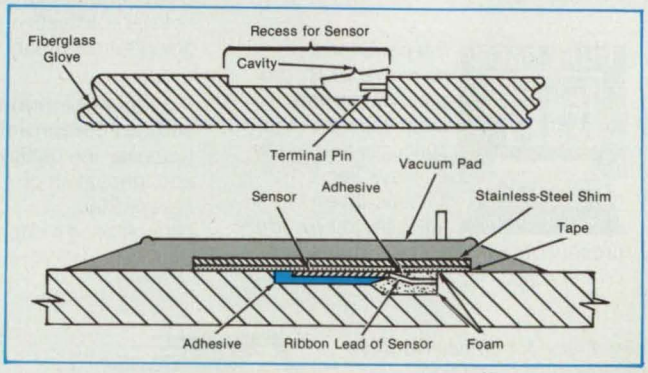
Flush Mounting of Thin-Film Sensors

The novel mounting technique requires a vacuum pad and customized materials.

Langley Research Center, Hampton, Virginia

A technique has been developed for mounting thin-film sensors flush with surfaces like aerodynamic surfaces of aircraft, which often have compound curvatures. In the application shown in the figure, a fiberglass glove that includes a recess for a sensor is attached to a wing for use in studying natural laminar flow. The sensor is to be mounted flush with the surface of this glove.

The technique involves the use of materials that have been tailored to the thermal (including thermal-expansion) properties of the substrate in which the sensor is to be mounted. One of the materials is an adhesive that is made by mixing 70 volume percent of an amorphous fumed silica with 30 volume percent of a two-component epoxy to obtain the desired viscosity and to match the thermal expansion of the cured mixture with that of the substrate. The relatively large volume of a cavity in the lowest part of the recess is filled with urethane foam, which does not produce large thermally induced stresses on the ribbon leads of the sensor.



A Sensor Is Mounted in a Recess by use of a vacuum pad and materials selected for the specific application.

First, the upper part of the recess is filled with the adhesive. Then the sensor, attached to the underside of a strip of Kapton® tape that covers the recessed area and acts as a carrier for the sensor, is positioned in the recess. A stainless-steel shim is placed over the tape. A vac-

uum pad is placed over the shim to provide a uniform surface pressure while evacuating the volume above the sensor.

After the adhesive has been cured, the ribbon leads of the sensor are soldered to terminal pins, and the cavity at the bottom of the recess is filled with urethane foam. The foam is shaped to be totally confined to the cavity and to protrude up to near the surface. More adhesive is then used to fill the volume over the foam. The excess adhesive is faired to conform to the surrounding surface by use of a fine-grit abrasive paper under a microscope.

This technique, together with customized materials, should enable the flush mounting of thin-film sensors in most situations in which recesses for the sensors can be provided. The technique should be useful in both the aircraft and the automotive industries.

This work was done by Thomas C. Moore, Sr., of **Langley Research Center**. *No further documentation is available.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 30]. Refer to LAR-14446.

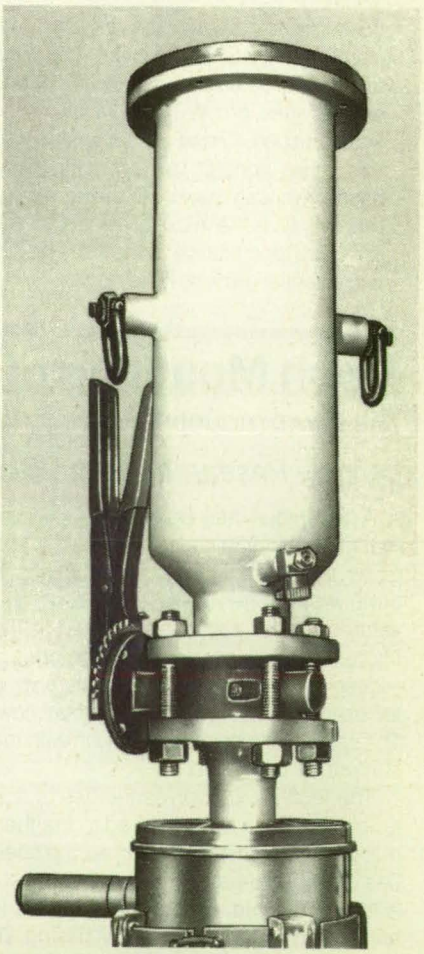
Container Prevents Oxidation of Metal Powder

Metal is kept uncontaminated until used in vacuum plasma spraying.

Marshall Space Flight Center, Alabama

A sealed high-vacuum container holds metal powder that is required to be kept free of contamination by oxygen from the point of manufacture to the point of use at a vacuum-plasma-spraying machine. The container protects the powder from the air during filling, storage, and loading of the spraying machine. It eliminates unnecessary handling and transfer of powder from one container to another.

Previously, metal powders were shipped in small glass bottles or cans. A technician transferred the powder from such a container to a canister on the powder feeder



The **Stainless-Steel Container Sits** on the powder feeder of a vacuum-plasma-spraying machine.

of the vacuum-plasma-spraying machine. This procedure required time-consuming handling of the material and presented opportunities for accidental contamination of the powder with oxygen.

The new container (see figure) consists mostly of a stainless-steel cylinder that holds 50 pounds (22.7 kilograms) of powder. It is vacuum-rated to 10^{-4} torr (about 10^{-2} Pa). It is equipped with a valve for loading and unloading, a port for monitoring the residual gas content, and a purge valve. Lugs for lifting the container are provided, and a flat base allows for easy storage.

This work was done by William H. Woodford, Christopher A. Power, Timothy N. McKechnie, and David H. Burns of Rockwell International Corp. for **Marshall Space Flight Center**. *For further information, Circle 68 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 30]. Refer to MFS-29861.

Tools Make Clean Holes in Honeycomb Panels

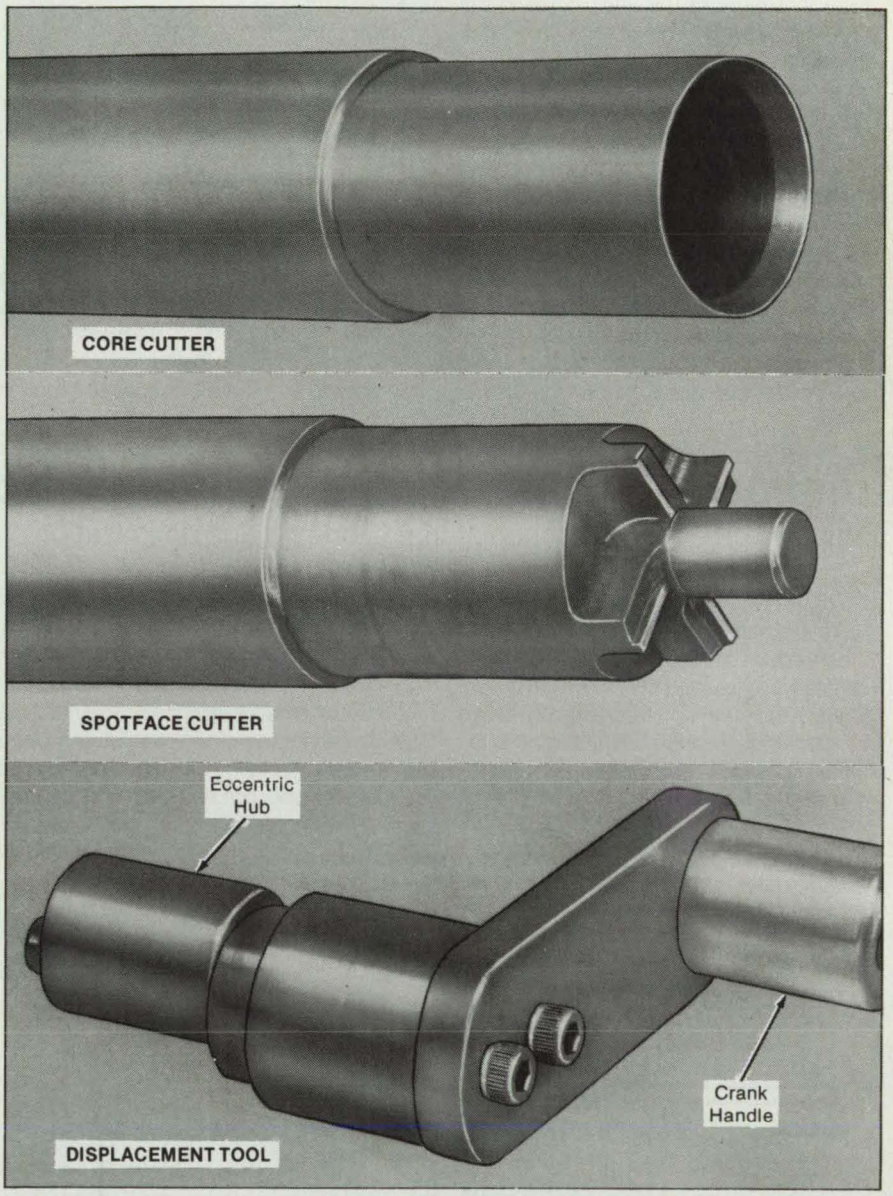
Holes for mounting hardware can be made quickly.

Goddard Space Flight Center, Greenbelt, Maryland

Three tools are designed to be used together to prepare honeycomb panels for insertion of hardware to support structural members or electronic packages. The tools speed up and simplify the time-consuming operation of manually pushing honeycomb material aside to make room for a spool-shaped mounting insert.

The tools are a core cutter, a spotface cutter, and a displacement tool (see figure). The preliminary operation involves making a clearance hole on true position through the front skin of a honeycomb panel. The panel is turned over and a hole is cut through the back skin to the diameter of the spool. The technician then uses the sharp-edged core cutter to remove a cylindrical slug from the honeycomb cell. The technician then rotates the spotface cutter in the hole made by the core cutter to remove any remaining adhesive. Finally, the technician inserts the eccentric hub of the displacement tool in the hole and rotates the crank of this tool to enlarge and finish the hole. The panel is then ready for insertion of a mounting spindle.

This work was done by Dott Wells of **Goddard Space Flight Center**. *For further information, Circle 27 on the TSP Request Card.*
GSC-13416



These **Tools Make Clean Holes** in honeycomb panels to receive spool-shaped mounting inserts.

Thermally Activated Retainers for Insertion in Gaps

Inserted while flat, retaining strips later develop tabs that hold them in place.

Lyndon B. Johnson Space Center, Houston, Texas

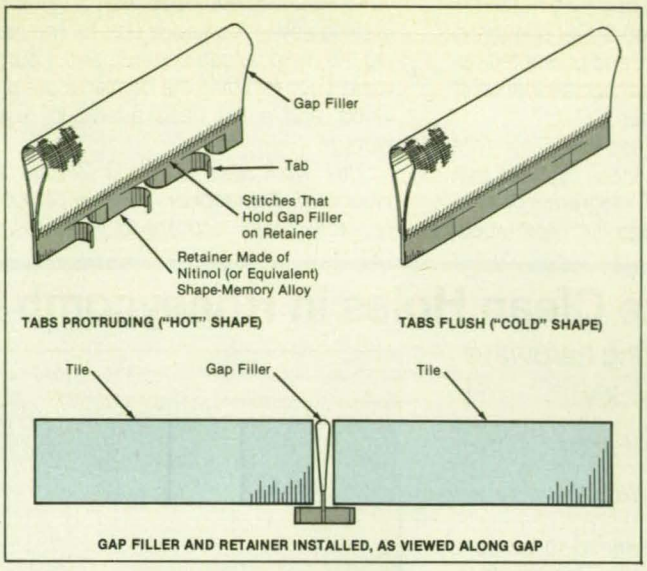
Proposed mechanical retainers of a new type for use with gap filler promise to be easy to install and to attach themselves securely. The retainer concept is based on the shape-memory properties of the metal alloy Nitinol, an alloy of nickel and titanium.

The retainers were conceived for use with the Space Shuttle insulating tiles but could also presumably be used in other assemblies of blocks or tiles that are configured similarly. The retainers would be used in place of the present gap-filling system, in which solid gap fillers are secured in the gaps by use of room-temperature-vulcanizing silicone rubber. Installation by use of the silicone rubber is difficult and time consuming, and the resulting bond is unreliable.

A retainer of the proposed type would provide a positive, adhesive-free attachment that would utilize the normally inaccessible undersides of the adjacent tiles. One version of the retainer would be made from

a strip of Nitinol approximately 0.02 in. (0.5 mm) thick, into which a series of tabs has been stamped (see figure). The gap filler — a loop of ceramic cloth — would be attached to the retainer by gluing or sewing. In fabrication, the retainer would be subjected to a sequence of tab-bending and tab-straightening steps at different temperatures above and below the transition temperature of the Nitinol alloy, such that in the resulting "remembered" higher-temperature shape, the tabs would protrude from the plane of the strip, while in the "remembered" lower-temperature shape, the tabs would be flush with the strip.

To prepare for insertion into the gap between a pair of adjacent tiles, a retainer-and-gap-filler assembly would be cooled: this would make the tabs flush, enabling them to fit in the gap. After insertion, the retainer would be heated above the transition temperature, perhaps by allowing it to warm up to ambient temperature or perhaps by heating with a resistance wire. This warming would make the tabs spring into the bent-outward configuration. This would secure the tabs firmly under the tiles.



Tabs Bent Outward would be made flush by cooling below the memory transition temperature. Finally, after insertion in the gap and reheating, the tabs would spring outward.

This work was done by Margaret E. Grimaldi and Leslie S. Hartz of **Johnson Space Center**. *For further information, Circle 78 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center [see page 30]. Refer to MSC-21793.

Improved Fluidized-Bed Reactor With Horizontal Staging

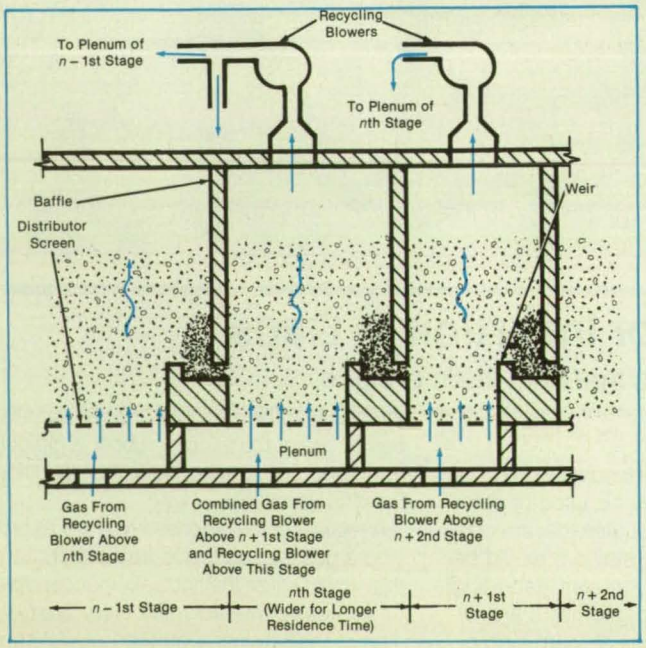
This design promotes conservation of energy and optimization of flows and residence times.

Lyndon B. Johnson Space Center, Houston, Texas

The design of a fluidized-bed reactor that contains multiple, horizontally arrayed stages (see Figure 1) offers several advantages over present multistage fluidized bed reactors with horizontal, vertical, or slanted stacking:

- The number of stages can be greater than in a vertically stacked reactor where headroom limits height, and the ancillary structure required to support the stack can be smaller than in vertical stacking.
- The entire top of the reactor can be removed, exposing all stages of the reactor for inspection and maintenance; such maintainability is difficult to achieve in a vertical-stacking design.
- Most of the wall area of the individual beds in the new reactor is exposed only to adjacent beds. Thus, heat is retained better than in a vertical design, in which the entire circumference of each bed is

Figure 1. This **Fluidized-Bed Reactor With Horizontally Stacked Stages** offers several advantages over vertically stacked and prior horizontally stacked reactors.



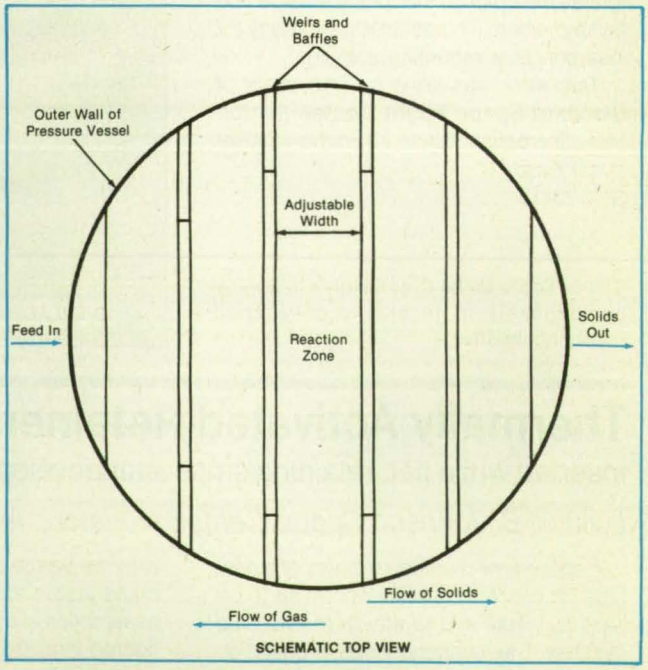


Figure 2. For **High-Pressure Reactions**, a fluidized-bed reactor containing stages stacked horizontally within a cylindrical pressure shell might be preferred.

exposed to the environment.

- The overflows between stages contain nonfluidized solids, which tend to insulate the lower portions of the stages from each other.
- The horizontal length of each stage, and hence the cross section presented to the vertical flow of gas, can be varied independently if control of the velocity of the gas is required — as when it is desirable to suppress those changes in pressure or temperature between stages that would adversely affect the operation of the reactor. Such control cannot be effected as easily in a vertically stacked design, because in vertical stacking, the diameter of the reactor is usually kept constant with height.
- If a longer retention time is required, the horizontal length of the bed can be increased to increase the volume of the bed. Ungainly bed heights, with resultant high pressure drops, would be required in a standard vertical design.

In the new reactor, the solids proceed from one stage to the next by flow over a weir. Once the fluidized solids enter the nonfluidized zone near each weir, they form a less permeable bed that partially seals the adjacent stages from interchanges of gas. The effectiveness of the seal depends on the differential pressure, the nature of the solids, and the adjustable height of the weir, but slight leakage from one stage to the next may be quite acceptable. If not, a small stream of stripper gas can be introduced.

The upper portions of the stages are separated by baffles, thus producing distinct disengaging zones for separation of fines. The combination of the weirs and baffles provides for the separation of the stages in both the fluidized-solid and gas phases.

The gas venting from the top of the last stage is fed to the plenum of the penultimate stage to fluidize its bed; the vent from this stage is sent to the bed preceding it; etc. No other horizontally arranged staged beds provide countercurrent flow of the gas. There are two ways to force the pressure drop to be in the direction required to make the gas flow countercurrent to the solids: (1) the pressure can be made to cascade downward along the entire length of the reactor or (2) intermediate increases in pressure can be provided with additional compressors or blowers.

Any of the presently used methods of feeding and removing solids from fluidized beds can be applied in this reactor. "Air slides" or other gas-controlled devices might be preferred because they can be used to extend the staging concept. If high pressures are to be used, or if floor area of the equipment must be kept small, a cylindrical pressure shell may be called for. The plan view for this is shown in Figure 2.

This work was done by Thomas A. Sullivan of **Johnson Space Center**. *For further information, Circle 17 on the TSP Request Card.*

MSC-21844

Dielectric-Particle Injector for Processing of Materials

Dielectric particles or droplets are electrically charged and electrostatically projected.

NASA's Jet Propulsion Laboratory, Pasadena, California

The device illustrated schematically in the figure generates electrically charged particles of solid, or droplets of liquid, fabricated from dielectric material and projects them electrostatically, possibly injecting them into an electrostatic-levitation chamber for containerless processing. Previously, the electrostatic-injection technique was limited to electrically conductive droplets, greatly limiting the variety of materials that could be processed.

The droplets or particles of the material to be injected are placed initially in the injector on a plate of zinc or other metal chosen because it has a low work function. The plate is biased at a negative electrostatic potential with respect to ground. A highly transparent, coarse, electrically grounded wire grid is located 1 cm above the plate so that there is a strong electric field at the surface of the plate. The plate is illuminated by an ultraviolet source that emits at wavelengths from 2,000 Å to 3,000 Å.

Because of the low work function of the plate, the ultraviolet illumination readily causes the emission of photoelectrons from the plate. Few photoelectrons are emitted from the dielectric particles or drops because dielectric materials usually have work functions much greater than that of zinc. When the photoelectrons emitted from the plate collide with the dielectric particles or droplets, the particles or droplets become negatively charged. The electric field acts on the charged particles or droplets, pulling them away from the plate. Most of these particles or droplets pass through the wire grid. They can then be trapped by use of the proper electrostatic levitating and confining field.

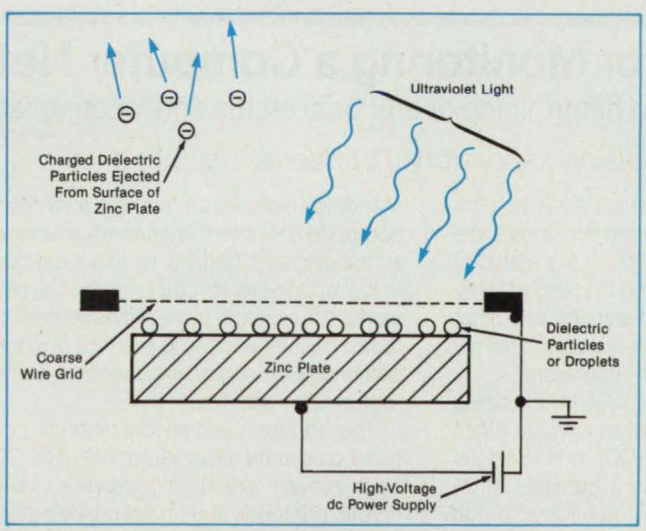
This injector has been tested in a laboratory, using glass microballoons as the dielectric particles. These microballoons were ejected from the zinc surface at an applied potential of 1 kV. A relatively large electrostatic force was needed to overcome gravitation and adhesion of the microballoons to the plate.

This work was done by Philip L. Leung and Stephen B. Gabriel of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 46 on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Edward Ansell
Director of Patents and Licensing
Mail Stop 305-6
California Institute of Technology
1201 East California Boulevard
Pasadena, CA 91125

Refer to NPO-18299, volume and number of this NASA Tech Briefs *issue, and the page number.*



The **Dielectric-Particle or -Droplet Injector** charges dielectric particles or droplets on a zinc plate with photoelectrons generated by ultraviolet illumination, then ejects the charged particles or droplets electrostatically from the plate.

Mathematics and Information Sciences

Accelerating Learning by Neural Networks

Teacher forcing functions are applied initially, then gradually diminished.

NASA's Jet Propulsion Laboratory, Pasadena, California

Electronic neural networks can be made to learn faster by use of terminal teacher forcing. This is a method of supervised learning that involves the addition of teacher forcing functions to the excitations that are fed as inputs to the output neurons. Initially, the teacher forcing functions are strong enough to force the outputs to the desired values; subsequently, these functions decay with time. Teacher forcing is analogous to the traditional method by which a parent teaches a child to ride a bicycle: initially, the parent holds the bicycle; as learning progresses, the parent releases the bicycle and stands back for longer periods, eventually withdrawing from the scene when learning is complete.

The evolution of a neural network during learning is represented by

$$\dot{u}_n + k_n u_n = g_n[\gamma_n(\sum_m T_{nm} u_m + I_n)] \quad t > 0$$

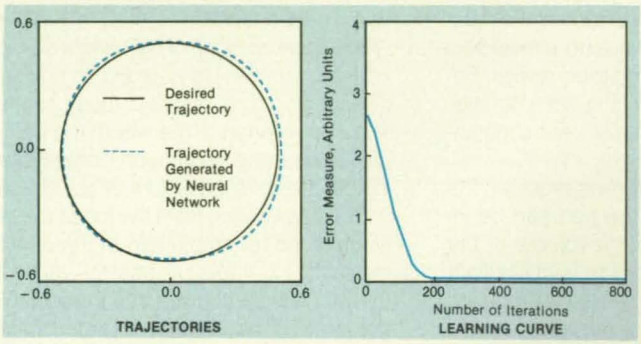
where t denotes time, u_n denotes the output of the nth neuron and T_{nm} denotes the synaptic coupling from the mth to the nth neuron. The constant k_n characterizes the decay of neuron activity. The response of the nth neuron is governed by the sigmoidal function g_n and gain γ_n; typically, $g_n(\gamma x) = \tanh(\gamma x)$. The time-dependent term, $I_n(t)$, called the "source" term, encodes the contribution of the nth component, $a_n(t)$, of the pattern to be learned, via the following equation:

$$I_n(t) = \begin{cases} a_n(t) \text{ if the } n\text{th neuron is an input neuron;} \\ 0 \text{ if the } n\text{th neuron is a hidden neuron; or} \\ \lambda[a_n(t)]^{1-\beta}[a_n(t) - u_n(t)]^{\beta} \text{ if the } n\text{th neuron} \\ \text{is an output neuron.} \end{cases}$$

The third version of the equation specifies the teacher forcing function. At the present state of development, λ is a positive constant. When $\beta = (2i+1)^{-1}$ and i is a strictly positive integer, the teacher forcing function induces a terminal-attractor phenomenon into the dynamics of the network. This is the mathematical meaning of "terminal teacher forcing." When the learning is successfully completed, terminal teacher forcing vanishes, and the dynamics of the neural network become equivalent to those of a conventional neural network.

The problem in learning is to adjust the synaptic couplings, T_{nm}, in such a way as to minimize a quadratic measure of the errors in the outputs. These adjustments are made iteratively; they involve computations of gradients of the error measure in T_{nm} space, as well as other computations, all of which are beyond the scope of this article.

The terminal-teacher-forcing concept was tested by computer simulations of a network of six fully connected neurons (zero input, four hidden, two output) learning to produce time-varying Cartesian coordinates of a circular trajectory. The figure illustrates the result of one simulation, in which learning was nearly complete after 400 iterations. In contrast, neural-network-training method previously published in the open literature, required about 12,000 iterations to teach a circular trajectory.



The Simulated Neural Network With Terminal Teacher Forcing learned to produce a close approximation of a circular trajectory in 400 iterations.

This work was done by Nikzad Toomarian and Jacob Barhen of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 92 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 30]. Refer to NPO-18553.

Software for Monitoring a Computer Network

SNMAT assists in determining operational status and locating faults.

NASA's Jet Propulsion Laboratory, Pasadena, California

SNMAT is a prototype rule-based expert-system computer program designed to assist personnel in monitoring the status of a computer network and in identifying defective computers, workstations, and other components of the network. It will also assist in training network operators.

The network for which SNMAT is being developed is located at the Space Flight Operations Center (SFOC) at NASA's Jet Propulsion Laboratory; it consists of 21 software and hardware subsystems that process telemetry data from, and commands for, spacecraft, and will soon support up to 6 different spacecraft missions simultaneously. SNMAT is also expected to be adaptable to other computer networks; for example in the management of repair, maintenance, and security, or in the administration of planning systems, billing systems, or archives.

The commercial network-testing computer programs used heretofore at SFOC have proved tedious in operation, yield cryptic printouts, and do not provide diagnostic routines with context-sensitive help systems. SNMAT is intended to serve as a data-reduction system that can provide windows, menus, and graphs, thereby enabling users to focus on relevant information.

SNMAT is constructed by use of the Sun Common Lisp 2.1 language and the Automated Reasoning Tool (ART) version 3.1, which is an expert-system software shell that provides a powerful knowledge-representation language and is extendable, yet maintains rule processing at high speeds.

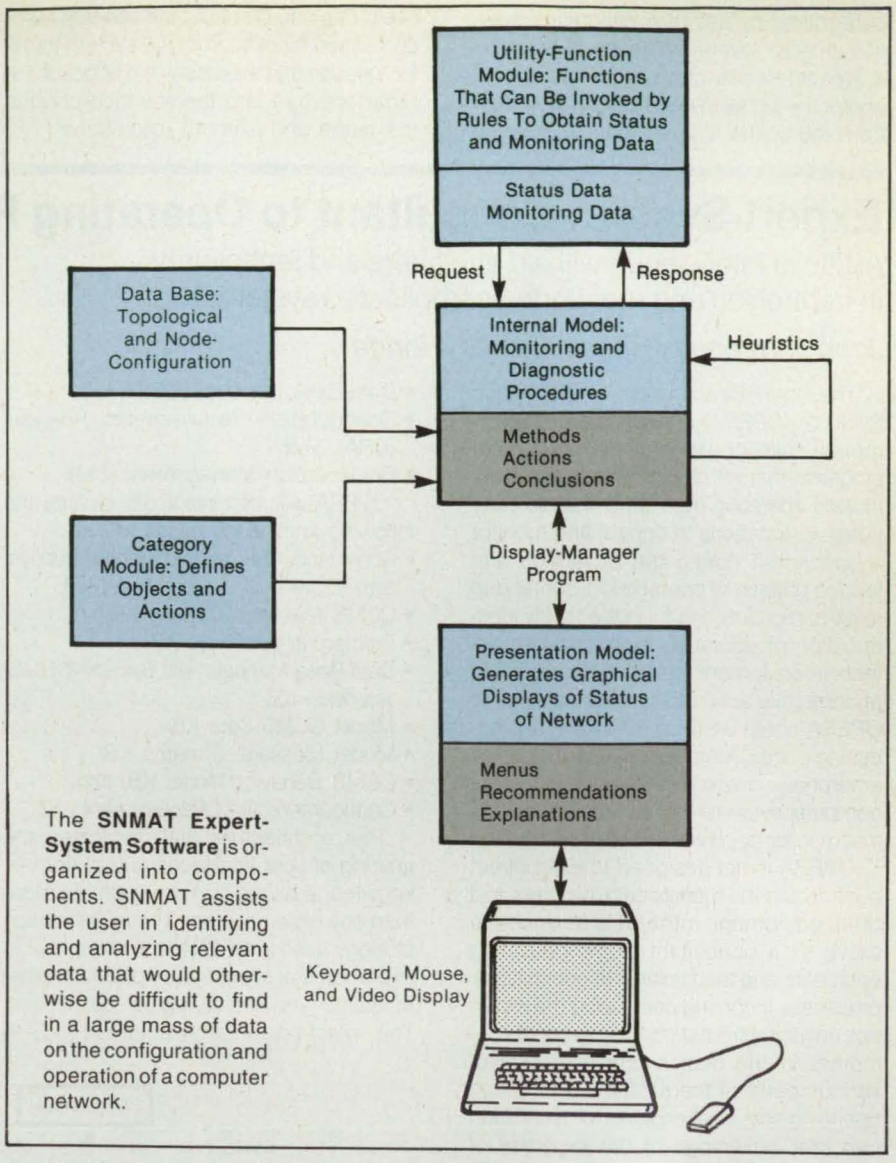
SNMAT (see figure) incorporates an object-oriented design and programming

technique that allows the creation of generic classes, objects, rules, and methods. This design and programming technique provide dynamic binding of functions to objects, inheritable objects and methods, and abstraction of objects through both relational and object-oriented representation of data. This approach allows categories of objects (components of the network) to be organized into separate entities so that when a new category of objects is created, the rest of the system need not be modified.

The services to be provided by SNMAT include the following:

- Rapid identification of faults, explanations of failures, and suggested remedies;
- Quick access to information on the location, serial number, hardware, software, and statistics of utilization of each functioning or malfunctioning node of the network;
- A graphical display of the network that can be modified and tested by simulation;
- Monitoring of status of the network via reception of messages broadcast by all nodes;
- Graphical display of statistics (e.g., volumes of traffic) on operation of the network;
- Interactive presentation of selected data overlaid on topological and/or geographical depictions of the network; and
- Relatively sophisticated expert-system reasoning with incomplete, uncertain, and ambiguous data to complement the work of human experts.

This work was done by Young H. Lee of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 58 on the TSP Request Card.*
NPO-18329



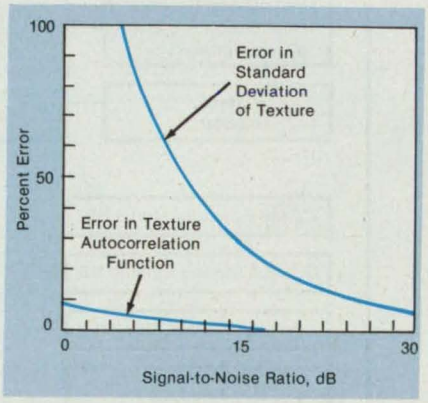
The **SNMAT Expert-System Software** is organized into components. SNMAT assists the user in identifying and analyzing relevant data that would otherwise be difficult to find in a large mass of data on the configuration and operation of a computer network.

Statistical Approach to Extraction of Texture in SAR

The effects of sampling, resolution, system noise, and speckle are taken into account.

NASA's Jet Propulsion Laboratory, Pasadena, California

An improved statistical method of extraction of textural features in synthetic-aperture-radar (SAR) images takes account of the effects of the scheme used to sample the raw SAR data, the system noise (which includes thermal noise, quantization noise, and other components), the resolution of the radar equipment, and speckle. This and other methods of extraction of textural features are important because they aid in discrimination between different targets in SAR images. One major purpose in developing this method was to overcome deficiencies in treating speckle in prior methods. For example, removing speckle from an image by simple smoothing also destroys all the other information about the radar-backscattering properties of the scene.



System Noise Gives Rise to Errors and thereby makes it more difficult to extract textural features. However, as shown here, the errors are large only at small signal-to-noise ratios.

In the improved method, the treatment of speckle is incorporated into an overall statistical treatment of the speckle, system noise (see figure), and natural variations in texture. The first-order statistics of texture are characterized by use of the standard deviation of texture. The second-order statistics of texture are characterized by the area of the texture autocorrelation coefficient, as expressed by an equation that incorporates the standard image autocorrelation coefficient and the speckle autocorrelation function.

The texture autocorrelation function is estimated by removing the speckle autocorrelation function from the image autocorrelation function, by use of what is essentially an inverse-filter computation. The speckle autocorrelation function can be

determined by use of a calibrating scan of a smooth, low-return scene. In practice, a smooth scene can be difficult to find and/or the signal-to-noise ratio of the return from the scene may be too low. Alternatively, one can compute the speckle autocorrelation function from the system transfer function that expresses the effect of the radar aperture and thereby incorporates the range and azimuth resolutions.

This work was done by Eric J. Rignot and Ronald Kwok of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 32 on the TSP Request Card. NPO-18259*

Expert-System Consultant to Operating Personnel

Artificial intelligence will aid engineers and technicians in controlling and monitoring complicated systems.

John F. Kennedy Space Center, Florida

The Operations Analyst for Distributed Systems (OPERA) software is a developmental suite of expert-system computer programs that will help engineers and technicians operating from a number of computer workstations to control and monitor a spacecraft during the prelaunch and launch phases of operation. It is intended to be particularly helpful in the timely identification of operating problems and defects in equipment, and in the formulation of corrective actions. Modified versions of OPERA could be used in chemical-processing plants, factories, banks, and other enterprises in which there are distributed-computer systems that include computers that monitor or control the other computers.

OPERA is not designed to exert direct control over the monitored computers and other equipment: rather, it is designed to serve as a consultant to the operating engineers and technicians. In effect, it preprocesses incoming data, using the expertise collected from a conglomerate of specialists in the design and operation of various parts of the system. Thus, each operating specialist engineer or technician can take advantage of the expertise of other specialists, drawing on such knowledge as solutions to similar problems encountered in the past.

OPERA is based on a modular and flexible distributed architecture, in which expert-system programs are embedded within individual "blackboard" computer programs. Communications and coordination are managed by a dedicated controller "blackboard" computer program called the "OPERA controller." The expertise from each specialty ("domain knowledge") is codified within a knowledge base. All of the information processed via the various expert-system programs and knowledge bases is consolidated by the OPERA controller, which resolves disagreements, thereby helping to assure the reliability of the incoming data and suggesting solutions to problems.

The figure illustrates this architecture, showing current and anticipated future modules. When fully developed, OPERA will include the following six expert-system software modules:

- Real-Time System Error Management (RTSEM),
- Problem Impact Analysis (PIA),
- Model-Based Fault Isolation (MBFI),
- Data-Base Interface (DBIF),
- Configuration Requirements Analysis (CRA), and
- Configuration Management (CM).

OPERA will also eventually include the following knowledge bases (KB's):

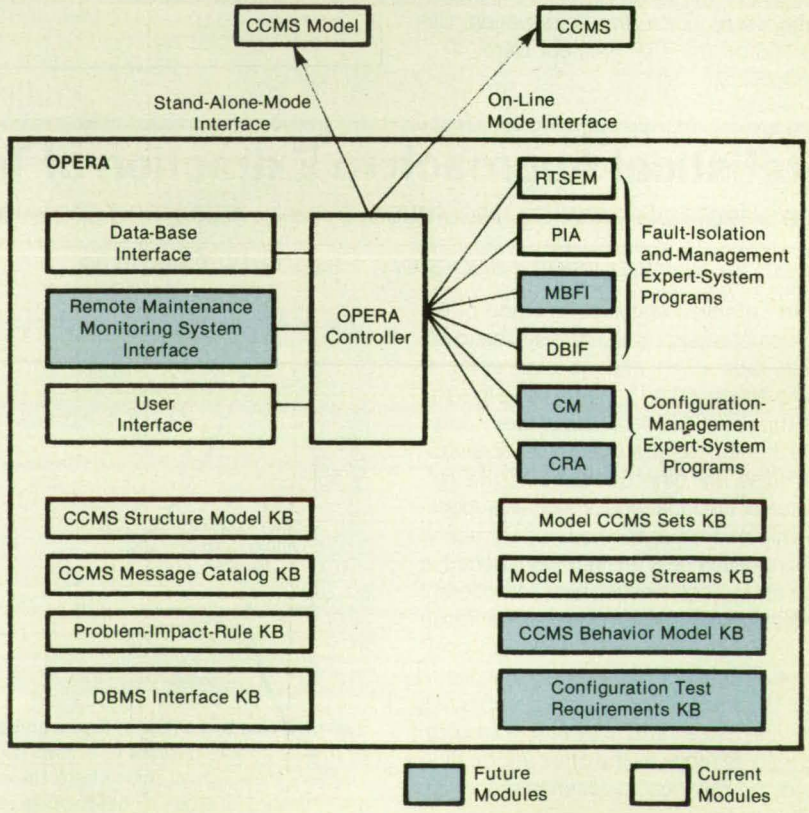
- Command, Control, and Monitor Subsystem (CCMS) Structure Model KB,
- CCMS Message Catalog KB,
- Problem-Impact-Rule KB,
- Data-Base-Management System (DBMS) Interface KB,
- Model CCMS Sets KB,
- Model Message Streams KB,
- CCMS Behavior Model KB, and
- Configuration Test Requirements KB.

This architecture also facilitates the sharing of user interfaces and of domain knowledge bases that are useful in more than one expert system. The fault-isolation strategy used in OPERA is also applicable to problems of interpretation of data in other scientific and technological disciplines. The "blackboard" architecture of OPERA is similarly generalizable.

The OPERA system is not driven by keyboard commands, but by menus and mouse-activated commands. Multiple screens are used and operate with both plain English and graphical interfaces. When queried, OPERA then shows the user a possible solution to the problem. When fully developed, OPERA will function in real time; at present it does not, but instead receives input in the form of processed data, recorded on tape.

This work was done by Astrid E. Heard and Patrick P. Pinkowski of **Kennedy Space Center**, *Richard M. Adler of The Mitre Corp., and R. Bruce Hosken of Grumman Corp. For further information, Circle 14 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Kennedy Space Center [see page 30]. Refer to KSC-11509.



The **Modular Architecture** of OPERA facilitates expansion and adaptation to different systems.

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More Genetic Engineering With Cloned Hemoglobin Genes

Cells are modified to enhance growth and the production of proteins.

NASA's Jet Propulsion Laboratory, Pasadena, California

A method for enhancing both the growth of micro-organisms in vitro and the production of various proteins or metabolites in these micro-organisms provides for the incorporation of selected chromosomal or extrachromosomal deoxyribonucleic acid (DNA) sequences into the micro-organisms from other cells or from artificial sources. The incorporated DNA includes parts that encode the desired product(s) or characteristic(s) of the cells and parts that control the expression of the product- or characteristic-encoding parts in response to variations in the environment.

The method combines and extends the concepts introduced in "Cloned Hemoglobin Genes Enhance Growth of Cells" (NPO-17517) and "Environmental Control of a Genetic Process" (NPO-17576) [both articles in *NASA Tech Briefs*, Vol. 15, No. 1 (January 1991), page 54]. In the method described in the first of the two prior articles, plasmids are used as vectors to transfer hemoglobin-encoding DNA sequences from *Vitreoscilla* bacteria (which produce hemoglobin) into *Escherichia coli* bacteria (see figure). This causes the *E. coli* to produce hemoglobin, which, in turn, causes increases in the rate of growth and density of the *E. coli* cells.

In the method described in the second article, one exploits promoter/regulator DNA sequences, which determine the extent of eventual expression of such genes as the hemoglobin-producing DNA sequence, and which are sensitive to the environment. To implement this method, one manipulates the chemical composition, temperature, or some other aspect of the environment to increase or decrease the growth of cells and/or the production of a given substance. In the specific application tested, one decreases or increases the concentration of oxygen in the culture medium, thereby causing the recombinant *E. coli* to produce more or less hemoglobin, respectively.

The oxygen-binding proteins can be used to increase not only the proteins and metabolites naturally made by cells but also unnatural proteins and metabolites. For example, in one experiment, a plasmid that contained the gene for chloramphenicol acetyltransferase was introduced into a natural strain of *E. coli* and a strain that contained the hemoglobin gene and its promoter from *Vitreoscilla*. The cells were grown in a fermentor in a buffered nutrient solution. When the concentration of oxygen fell below a limiting value, the cells that contained the hemoglobin gene produced significantly more chloramphenicol acetyltransferase.

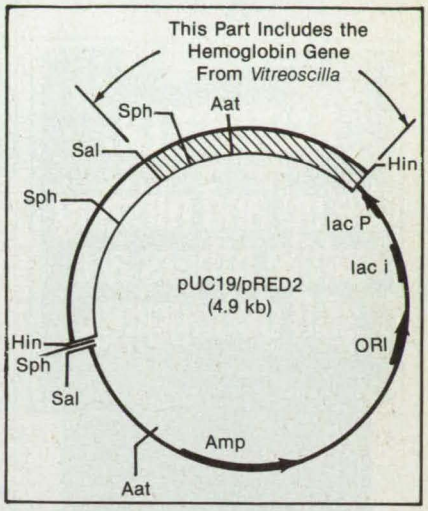
The extended method is expected to enable increased research into the growth of organisms in oxygen-poor environments. The hemoglobins or other oxygen-binding proteins can be used to enhance the supply of oxygen to cells or to chemical processes. Other proteins can be used as selective markers in research on recombinant DNA. Potential industrial applications may be found in the enhancement of those processing steps that require oxygen in fermentation, enzymatic degradation, treatment of wastes that contain toxic chemicals, brewing, and some oxidative chemical reactions.

This work was done by Chaitan Khosla and James E. Bailey of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 94 on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Edward Ansell
Director of Patents and Licensing
Mail Stop 305-6
California Institute of Technology
1201 East California Boulevard
Pasadena, CA 91125

Refer to NPO-18156, volume and number of this NASA Tech Briefs *issue, and the page number.*



This **Nucleotide Sequence** of the plasmid pUC19/pRED2 of *E. coli* includes a subsequence from *Vitreoscilla*, part of which encodes the *Vitreoscilla* hemoglobin protein. This figure differs slightly from the figure in one of the noted previous articles (NPO-17517).

Disinfecting Filters for Recirculated Air

Microbes are killed in a simple procedure.

Lyndon B. Johnson Space Center, Houston, Texas

A simple treatment disinfects air filters by killing bacteria, algae, fungi, mycobacteria, viruses, spores, and any other microorganisms that the filters might harbor. The treatment can be used on filters in air-circulation systems in spacecraft, airplanes, other vehicles, and buildings to help prevent the spread of colds, sore throats, and more-serious illnesses.

The concept has been applied to reusable stainless-steel wire mesh filters. First, the filters are rinsed to remove particles. Then they are immersed in a commercial disinfecting solution at room temperature. The filters are removed from the solution and allowed to drain. Then they are stored in plastic bags until needed for installation.

Disposable air filters can also be treated. They are sprayed with the disinfectant solution and immediately packed in plastic bags to retain the disinfectant vapor.

This work was done by Carmine A. Pilichi of Rockwell International Corp. for **Johnson Space Center**. *For further information, Circle 77 on the TSP Request Card.*
MSC-21783

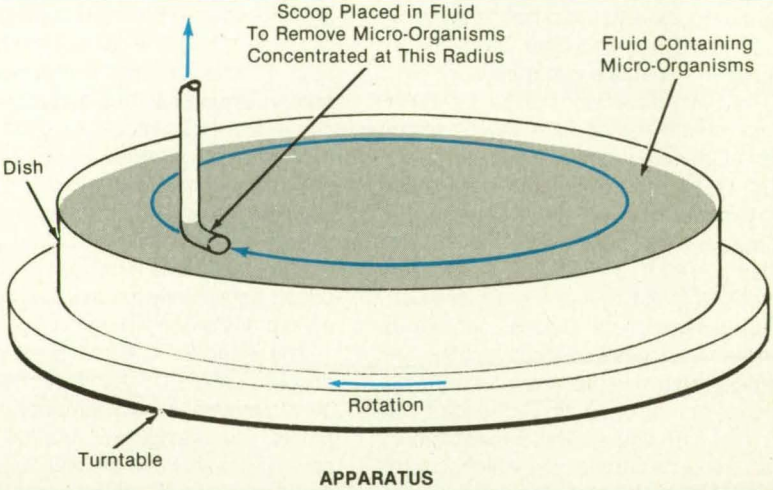
Rotary Apparatus Concentrates and Separates Micro-Organisms

Subtle interactions concentrate organisms into concentric rings.

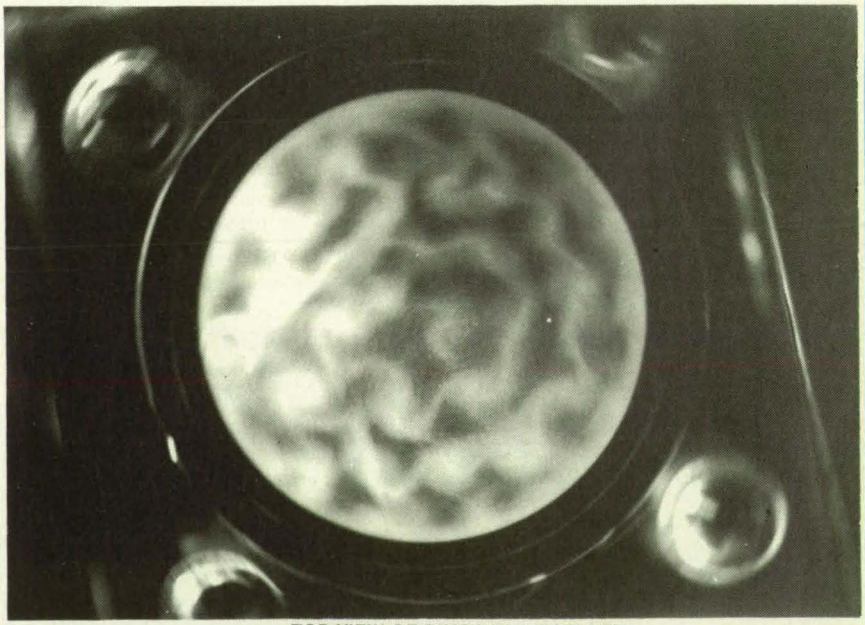
Marshall Space Flight Center, Alabama

The apparatus illustrated schematically in the figure concentrates and separates swimming micro-organisms of different species into concentric rings in a fluid. Fluid containing a high concentration of a desired species can then be removed by use of a small scoop placed into the fluid at the radius of one of the rings formed by that species. The apparatus has been demonstrated to concentrate algae (*Conium pectorale*, *Euglena gracilis* var. bacillarus, and *Polytomella parva*) and protozoa (*Tetrahymena pyriformis*).

Unlike prior devices that separate micro-organisms, this apparatus depends on the active participation of the organisms. It exploits the Coriolis force and bioconvection, which is a form of convection that evolves from the upward swimming and the competing effects of gravitation and diffusion. The prevalent upward swimming of some organisms results in the formation of a top layer of fluid containing a relatively high concentration of organisms and, consequently, having an elevated mass density. The elevated mass density gives rise to a gravitational instability, which turns the fluid over, just as the gravitational instability of a cooler, denser top layer of fluid turns the fluid over in thermal convection.



APPARATUS



TOP VIEW OF RINGS IN A ROTATED BIOCONVECTIVE CULTURE

Micro-Organisms Are Concentrated Into Concentric Rings by the combined dynamic effects of upward and horizontal components of swimming, rotation of the dish, gravitation, and viscosity.

The apparatus includes a dish that is rotated in a horizontal plane and is filled with a fluid containing the micro-organisms, which could be algae or protozoa, for example. Typically, the dish is rotated at a speed of the order of a few hertz, and the initial concentration of organisms in the fluid is $> 5 \times 10^5$/mL. The combined effects of bioconvection, the Coriolis force (caused by the horizontal component of the swimming motion in the rotating reference frame), and viscosity focus the organisms into concentric rings in the fluid. Typically, the rings form in 5 to 30 seconds. The desired micro-organisms are then scooped out from the appropriate ring. If further separation and concentration are to be performed, the rotation is stopped and the dish is refilled; alternatively, the rotation can be continued and fluid added to the dish via an inlet.

This work was done by David A. Noever of Universities Space Research Association for **Marshall Space Flight Center**. *For further information, Circle 10 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 30]. Refer to MFS-26124.

Secure Container for Discarded Hypodermic Needles

Needles are inserted through a self-closing lid and retained magnetically.

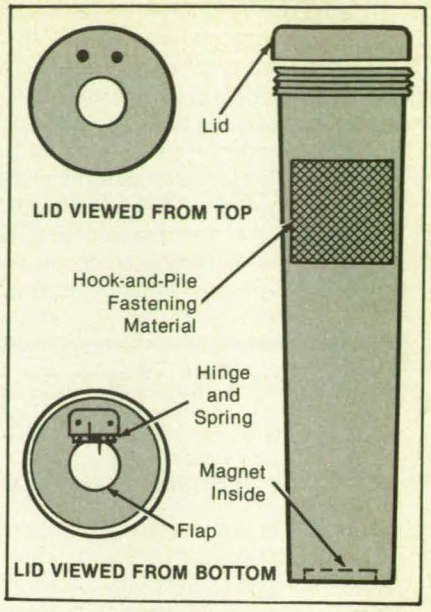
Lyndon B. Johnson Space Center, Houston, Texas

A container is designed for safe retention of discarded blood-collecting hypodermic needles and similar sharp objects that have been used in life-science experiments aboard a spacecraft. It could also be used on Earth to provide unusually secure containment of sharp objects.

Such containers — called "sharps containers" in the industry — are commercially available but are not suitable for use in the enclosed atmosphere and microgravity of the spacecraft environment. Being made largely of plastics, commercial sharps containers can outgas significantly, and in most cases, their designs are such that function and safety (including the ability to retain needles once inserted) depend on gravitation.

Several alternative designs were considered in the development of the microgravity sharps container. The design considerations were governed by the following goals: (a) to develop a design that addresses the special requirements imposed by the spacecraft environment (modifications of commercial units were eventually discarded) and (b) to respond to requests by astronauts that the use of the container require only one hand. To prevent outgassing, the container (see figure) is made almost entirely of metal. The main body of the container is a conically tapered anodized 6061-T6 aluminum cup that resembles a long drinking glass. An anodized 6061-T6 aluminum lid includes a rim with threads on its inner surface that mate with threads on the outer surface of the lip of the cup, in the manner of an ordinary threadable cap on a wide-mouthed jar.

Needles are inserted, sharp end first, through a small circular opening in the center of the lid. Most of the time, the opening is covered by a hinged, stainless-steel flap that is slightly larger than the opening and that is spring-loaded against the



This **Container Holds Used Hypodermic Needles** safely. Needles are inserted, sharp end first, through the spring-loaded flap. Long needles and needles on syringes cannot turn around in the container.

opening from the inside. To insert the needle into the container, one pushes the sharp end of the needle inward against the flap. Once the needle is all the way in, the flap snaps back to cover the opening. A magnet at the bottom of the cup attracts and retains needles, preventing them from floating around inside the container. As an added safety measure, the container is narrow enough that even if a large needle floats loose from the magnet, it cannot turn around so that its sharp end faces the opening. Thus, a previously inserted needle is unlikely to injure a person who subsequently inserts another needle.

The tapered shape of the container facilitates the stacking of several containers in storage. A patch of hook-and-pile fastening material (Velcro or equivalent) on the outside of the cup facilitates the mounting of the cup on a wall or workbench. The overall dimensions of the container are 2.65-in. (6.73-cm) diameter at the lid, 2.00-in. (5.08-cm) diameter at the bottom, and 10-in. (25.4-cm) length. The container weighs only 0.2431 kg. It can be emptied, cleaned, and reused.

This work was done by Angelene M. Lee of **Johnson Space Center**. *To obtain a copy of the report, "Sharps Container for the Inflight Blood Collection System," Circle 1 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center [see page 30]. Refer to MSC-21776.

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For More Information Circle No. 489

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

How Effective Is Communication Training for Aircraft Crews

Two training methods are studied.

A report surveys communication training for aircraft crews. Such training is intended to alleviate the problems caused or worsened by poor communication and coordination among crewmembers — problems that cause a high percentage of aviation accidents.

The report focuses on two training methods:

- Assertiveness training, which is under consideration by both the National Transportation Safety Board and the National Aeronautics and Space Administration for further development. In assertiveness training, the aim is to teach individuals to accept responsibility by expressing their concerns clearly and professionally, thereby improving communication and avoiding misunderstandings.
- Grid-management training, which is now in use by United Airlines. The grid-management concept places the highest value on a "team management" style — one that is based on high concern for both people and production, and in which work is accomplished by committed people. Their interdependence through a common stake in the purposes of the organization is supposed to lead to relationships of trust and respect.

The report examines the theoretical background of the methods and the attempts that have been made to validate their effectiveness. It presents criteria for evaluating their applicability to the aviation environment.

Communication training may be appropriate for aircraft crews, the report concludes, but there are many open questions about effectiveness and about transferring techniques from business, where they are widely used, to aviation. Nevertheless, further research is warranted. It is likely to produce reliable results, cost-effectively, for several reasons:

- Aviation presents a specific problem, and results can be quantified.
- Flight simulators are widely available to provide realistic settings.
- Aircraft crews present a homogeneous population, in terms of the tasks they perform and the training they have received.
- Crews in both military and commercial aviation are used to training and evaluation as part of their professional lives.

This work was done by Charlotte Linde, Joseph Goguen, and Linda Devenish of Structural Semantics for **Ames Research Center**. *Further information may be found in NASA CR-177459 [N88-26349], "Communication Training for Aircrews: A Review of Theoretical and Pragmatic Aspects of Training Program Design."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
ARC-12329

Laboratory Simulation of Upper-Body Work

A proposed exercise method would be more realistic than running or cycling.

A paper describes a proposed exercise method that would evoke muscular, cardiovascular, respiratory, and thermoregulatory responses typical of activity that involves the upper body, to simulate the effects of working in zero gravity in a space suit. The method would be used in research on the thermoregulatory subsystem of an advanced portable life-support system for a space suit.

The paper points out that such traditional laboratory exercises as walking and running on a treadmill and stationary cycling involve primarily the leg muscles, with little or no upper body work. In typical work in outer space, however, the lower-body muscles are used mainly to stabilize position; most of the astronaut's work is done with the upper body.

The report discusses the requirements for simulation of zero-gravity work in a space suit and describes the evolution of the proposed method through three versions. In the latest and preferred version, one would perform arm-crank ergometry with a gimbaled body-support mechanism that would react forces at the feet.

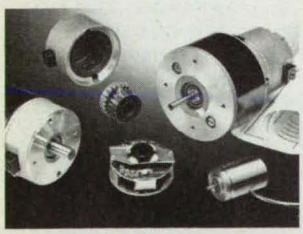
The report suggests activities to develop the method. These include experiments to refine the exercise concept, design and construction of an improved liquid-cooled garment, and formulation of an adaptive algorithm for feedback control of the liquid-cooled garment.

This work was done by R. Lantz of Sterling Software and H. Vykukal and B. Webbon of **Ames Research Center**. *To obtain a copy of the paper, "An Innovative Exercise Method to Simulate Orbital EVA Work: Applications to PLSS Automatic Controls," Circle 108 on the TSP Request Card.*
ARC-12966

New on the Market

Transtech Parallel Systems, Ithaca, NY, has announced the PARAstation series of **desktop parallel supercomputers**. The first in the series uses an MIMD architecture on Intel i860 64-bit microprocessors. Each machine has four processors with a peak performance of 320 MFLOPs, while more powerful networks can be formed by connecting the PARAstations. They have been designed to connect to Sun desktop SPARCstations via an Sbus interface board but can be linked to other host computers including VME-based Sun and Silicon Graphics workstations, and IBM PCs and PS/2s.
For More Information Circle No. 798

Cleveland Machine Controls, Billerica, MA, has introduced a line of brush-type DC **servo motors** available in five motor diameters and 21 motor lengths. Each motor has eight winding options to provide effective motion control solutions for such applications as machine tools, robotics, factory automation, and medical instrumentation. Further customization is achieved through options such as encoders, resolvers, tachometers, gearheads, and brakes, as well as various mounting configurations.
For More Information Circle No. 800



The Watchdog™ 300 manufactured by RGB Spectrum, Alameda, CA, **monitors, records, and transmits multiple video signals**. Exceptional clarity is achieved using a single monitor with more than four times the resolution of a video monitor. Each video signal is displayed in a window on the screen; a built-in switcher offers front-panel manual operation, remote sensor contacts, and computer control options.
For More Information Circle No. 788

The compact Scroller-Scope from Modular Instruments Inc., Malvern, PA, **shows waveforms on any VGA monitor** without the complications of a computer. Waveforms are captured in real time without the fadeout associated with conventional oscilloscopes. It also can function as a digital storage oscilloscope and provides negative-time triggering.
For More Information Circle No. 790

A high-performance **InGaAs PIN photodiode** with a 5 mm diameter active area has been introduced by Epitaxx Inc., West Trenton, NJ. Shunt resistance is 400 KΩ, with responsivity greater than 0.8 A/W at 1300 nm and capacitance less than 700 pF at -1.0 volt. Applications include fiber optic test and measurements, near-infrared laser detection, radiometry, and spectroscopy.
For More Information Circle No. 794

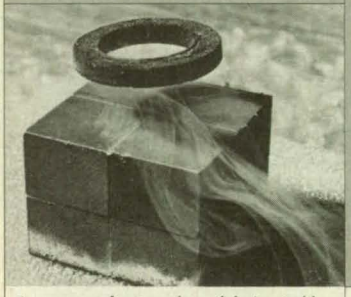
The model 84300 **disk memory system** from Raymond Engineering Inc., Middletown, CT, is a 300 MB design fully qualified to MIL-E-5400 Class II requirements without waivers. The system features a hermetically sealed and removable data cartridge and is suited for applications requiring extremely high reliably in demanding environments.
For More Information Circle No. 796

SigmaStat™, highly-automated **statistical software** for scientists, has been released by Jandel Scientific, San Rafael, CA. The package efficiently computes *t*-tests, analysis of variance, correlation, rates and proportions, nonparametric methods, linear and nonlinear regressions, power, and sample size.
For More Information Circle No. 792

New on the Market

A **programmable motion controller** for the PC bus from Galil Motion Control Inc., Sunnyvale, CA, employs a 32-bit specialized microprocessor and a custom sub-micron gate array. Available with 1-4 axes per card, it can be used with step motors, servo motors, and hydraulics. The controller features a 14-bit motor-command output DAC for precision and a novel PID filter with Kp, Ki, Kd, velocity, and acceleration feed-forward and integration units.
For More Information Circle No. 782

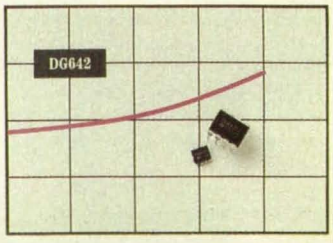
SANWA Components USA Inc., Marlboro, MA, has introduced the LSI series of high-speed, noncontact **memory cards**. The LSI is about the same size as a credit card and contains C-MOS-SRAM in 32, 128, 236, and 512 KB, or EEPROM memory in 8, 16, or 32 KB, with access speed as high as 500 KB/sec.
For More Information Circle No. 784



Superconductor rings fabricated by Fluoramics Inc., Mahway, NJ, are now commercially available to universities and industry for research purposes. Recent advances have enabled the company to produce rings of uniform quality. Made of yttrium, barium, and copper, they have a current of 3 amps and a high Meisner effect. The projected half life of the persistent current is 10^{23} years.
For More Information Circle No. 778

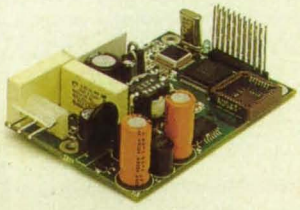
The Graphic Modeller from Mitchell Gauthier Associates, Concord, MA, provides a **graphical interface** to ACSL, the company's powerful simulation language, for true visual programming. The advance weds the power, flexibility, and rapid execution of ACSL with the ease and clarity of block diagrams. The Graphic Modeller can support simulations of large, multi-rate, hybrid systems with a digital controller and significant discontinuities.
For More Information Circle No. 774

The industry's first **monolithic CMOS analog switches** with on-resistance below 10Ω have been released by Siliconix Inc., Santa Clara, CA. The new switches allow designers of professional video equipment and high-precision test instruments to replace electromechanical relays with more durable, reliable, and energy-efficient semiconductor devices. The DG641 and DG642, which offer typical $r_{DS(on)}$ of 8Ω and 5Ω respectively, provide minimum signal crosstalk, low insertion loss, and negligible nonlinearity distortion.
For More Information Circle No. 786



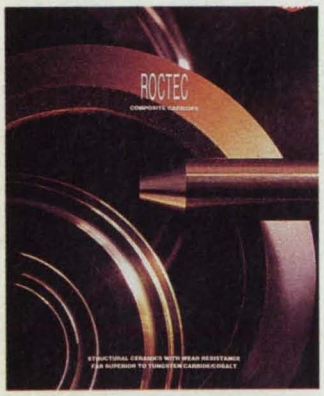
Microstar Laboratories, Bellevue, WA, has released version 4.0 of DAPL, a **multitasking, real-time software environment** that runs on the company's data acquisition processors. The update offers performance improvements of up to 600% compared to version 3.0. On-board data acquisition software can resolve problems associated with increasingly complex and resource-hungry PC platforms; for example, an intelligent board can monitor the critical real-time part of an application while Windows or OS/2 is redrawing the screen.
For More Information Circle No. 780

A family of **power line signaling products** developed by Echelon Corp., Palo Alto, CA, enables electrical devices in homes, buildings, and factories to communicate with one another through existing power lines. The innovative technology can be applied to automation of heating, air conditioning, and fire alarms, building-wide dimmer switches, sophisticated security systems, and train controls. The easy-to-install networks also provide a cost-effective means of supervising factory machine tools and robots without modifying plant wiring.
For More Information Circle No. 776



New Literature

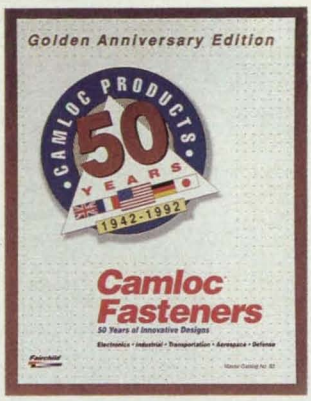
The *Concurrent Engineering Handbook* from Algor Inc., Pittsburgh, PA, is designed for users of the company's EAGLE (Engineering Application Generator, Language, and Environment) and other design and analysis tools to build, modify, and maintain a **concurrent engineering** model (CEM). The handbook provides real-world examples of EAGLE and CEM applications and serves as a reference guide to concurrent engineering principles, offering tips on such subjects as programming techniques and user interface design.
For More Information Circle No. 706



A brochure from Boride Products, a subsidiary of Dow Chemical Co., Midland, MI, provides performance and application data on ROCTEC® **composite carbides**. These advanced ceramics combine the corrosion-resistance and other properties of monolithic ceramics with wear behavior superior to existing ceramics and tungsten carbide/cobalt. They are suitable for use in cutting tools, blasting nozzles, wear plates, bearings, and similar applications where components are exposed to highly erosive, abrasive, and corrosive environments.
For More Information Circle No. 712

Grumman Measurement Standards Division, Bethpage, NY, has released a directory of available **calibration and repair facilities**. Grumman can provide the equipment, controlled environments, and expertise to calibrate and repair electronic, microwave, optical, and physical measurement devices.
For More Information Circle No. 704

A selection guide published by Elastomeric Technologies, Hatboro, PA, helps design engineers specify **elastomeric connections**. It provides specification ranges for the physical and electrical properties of various connection elements, chip sockets, and board-to-board and right-angle board connectors.
For More Information Circle No. 702



A 288-page catalog from Camloc Products, Hasbrouck Heights, NJ, features sections on ¼-turn and quick operating **fasteners**, Wedge-Tie™ PCB fasteners, and CoilThread® II tangless inserts. A wide selection of latches includes light- to heavy-duty tension latches and new one-piece elastomeric versions.
For More Information Circle No. 708

Rogers Corp., Rogers, CT, is offering a guide for economical machining of ENVEX **polyimide materials** into complex shapes—to tight tolerances with good surface finish—and for accurate and consistent part measurement. The materials offer excellent longevity, strength, and dimensional stability during continuous use at elevated temperatures. The brochure provides instructions for tooling, parts support, surface speed and feed rate, and coolant use.
For More Information Circle No. 714

Danfoss Electronics Inc., Rockford, IL, has introduced a 20-page brochure detailing its **adjustable speed drives for AC and DC motor control**. It features the VLT 3000 series of AC drives (spanning 1-100 hp), the Cycletrol series of DC controls, and the VariSpeed DC adjustable speed controls. The four-color publication illustrates applications in such automation-dependent industries as material handling and packaging.
For More Information Circle No. 710

Subject Index

(Continued on page 128)

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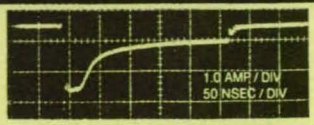

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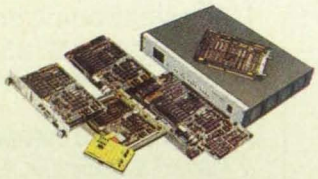

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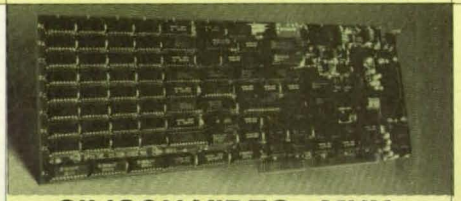

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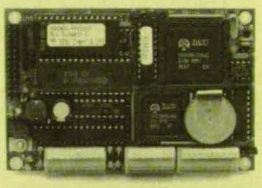

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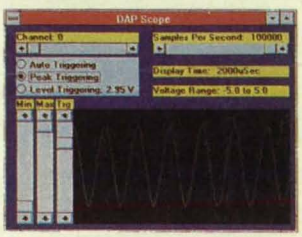

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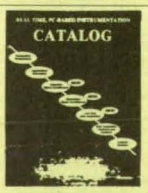

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Subject Index

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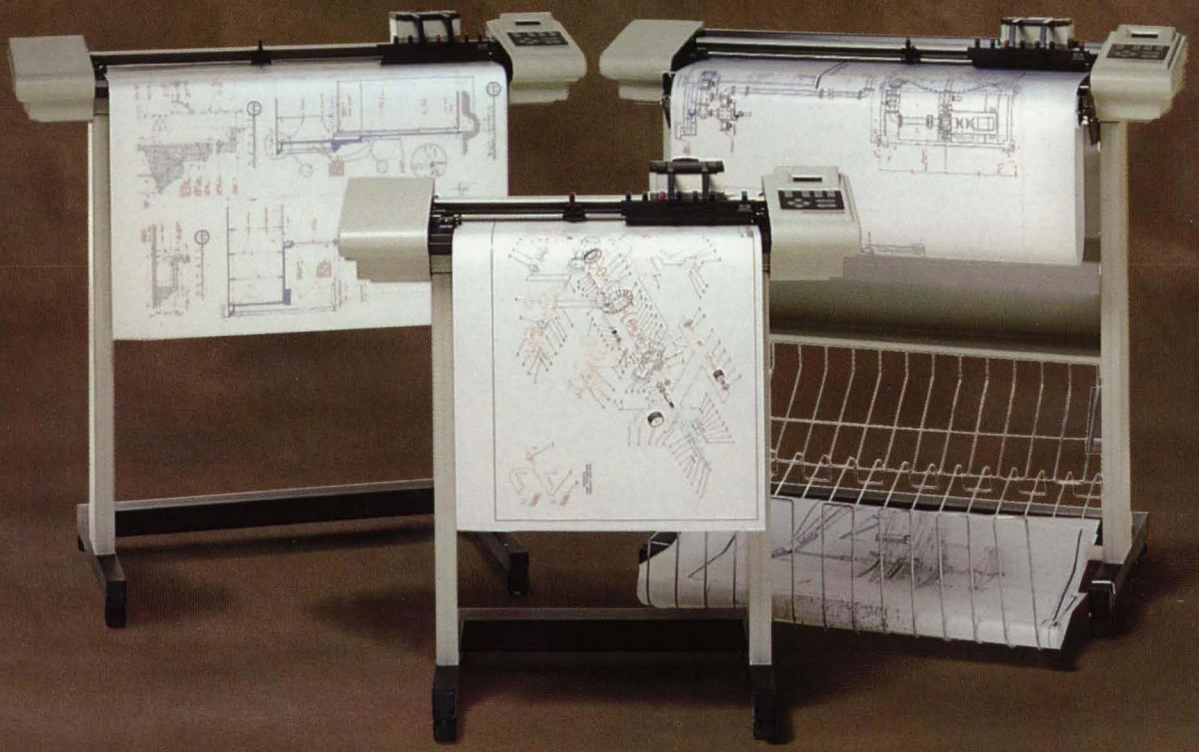

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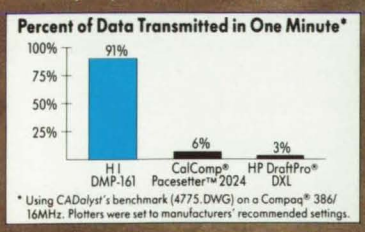

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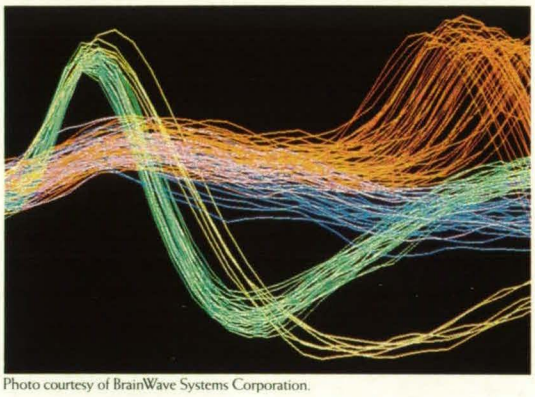

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